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2002 February 24

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2002 February 18

Draft Text for DO-242A

Presented by James Maynard

Edited by Stuart Searight

Contributions from:
Tony Warren
Richard Barhydt

Change History
This version of the paper, 242A-WP-12-01, supersedes the previous versions, 242A-WP-11-01, 11-01A, 11-01B, and 11-01C. Text that needs review is highlighted with a yellow background, while text that has been changed (since WP 11-01C) is indicated in color.
242A-WP-12-01A, 2001 February 15: Contributions from Jim Maynard and from Richard Barhydt have been merged into §2.1.2.19 to provide an overview of the "intent" features in this DO-242A version of the MASPS.
242A-WP-12-01A, 2001 February 15: A contribution from Stuart Searight, incorporating suggestions from Bill Harman and others, regarding changes to Table 3-4(a) and related text has been merged into §3.3.3.1.2.
242A-WP-12-01B, 2001 February 16: This is the version distributed by Stuart Searight prior to the meeting. It includes a few more contributions from Stuart and a few others.
242A-WP-12-01C: This draft shows changes edited into the document by Stuart Searight on Monday, February 18, during the first day of Meeting #12, and changes by Jim Maynard edited in that evening, in preparation for discussions on Tuesday, February 19.
242A-WP-12-01D, 2001 February 19: This draft shows changes edited into the document by Stuart Searight, acting as WG-6 secretary, during the discussions on Tuesday, February 10, together with changes edited in by Jim Maynard that evening to reflect decisions made on Tuesday. The latter changes affect the description the SV report (§3.4.3) and include moving the description of a transmitting participant's air/ground state from the MS report's OM codes (§3.4.4.10) to a subparagraph (§3.4.3.1) in the description of the SV report. These draft changes are to be reviewed by WG-6 on Wednesday, 2001 February 20.
242A-WP-12-01E, 2001 February 20: This draft shows changes inserted into the document by Stuart Searight during the WG-6 meeting on Wednesday the 20th, and by Jim Maynard that evening to reflect decisions made during the meeting that day: • "Airspeed Type (IAS/TAS/Mach) is moved from the Mode-Status (MS) report to the Air-Referenced Velocity (ARV) report. • A new On-Condition –Status Change (OC-SC) report is introduced to carry changes in certain fields in the Mode-Status and Trajectory Change reports
242A-WP-12-01E, 2001 February 20: In connection with the TCP terminology clarifications already being proposed in this document, I (Jim Maynard) am also proposing that the acronym TC be used for Trajectory Change, and that the Trajectory Change report be called the TC report. This will help, I think, to have clear names for certain fields in the TC report.
Version H of this Working Paper was prepared by Stuart Searight. In this version: • ALL changes agreed to at the WG6 February meeting have been incorporated; • Other "clean-up" editing has been done; • §3.4.4.3 has been added for a Mode Status element for ADS-B Version Number. • §3.4.9.8 has been modified with new material from Tony and Stuart • §3.4.9.23 has been added on TC Report management with material taken from the TC Management Indicator §.

RTCA, Inc.
1828 L Street NW, Suite 805
Washington, DC 20036, USA

Minimum Aviation System Performance Standards For Automatic Dependent Surveillance Broadcast (ADS-B)

Month dd, 2002
RTCA/DO-242A ***draft 1***

Prepared by: SC-186

Copies of this document may be obtained from

RTCA, Inc.
1828 L Street NW, Suite 805
Washington, DC 20036, USA

Telephone: 202-833-9339
Facsimile: 202-833-9434
Internet: www.rtca.org

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Forward

This report was prepared by Special Committee 186 (SC-186) and approved by the RTCA Program Management Committee (PMC) on <<Month dd, 2002>>. This document (RTCA/DO-242A) supersedes and replaces its first edition (RTCA/DO-242, dated February 19, 1998).

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2.1 General Requirements

2.1.1 General Performance

2.1.2 Information Transfer Requirements

The ADS-B system shall (R2.4) be capable of transmitting messages and issuing reports containing the information specified in the following subsections. This MASPS does not specify a particular message structure or encoding technique. The information specified in the following subparagraphs can be sent in one or more messages in order to meet the report update requirements specified in Section 3.

2.1.2.1 Time of Applicability (TOA)

The time of applicability (TOA) of ADS-B reports indicates the time at which the reported values were valid. Time of applicability shall (R2.3) be provided in all reports. Requirements on the accuracy of the time of applicability are addressed in Section 3.

2.1.2.2 Identification

The basic identification information to be conveyed by ADS-B shall (R2.5) include the following elements:

- Call Sign (§2.1.2.2.1)
- Participant Address (§2.1.2.2.2.1) and Address Qualifier (§2.1.2.2.2.2)
- ADS-B Emitter Category (§2.1.2.2.3)

The ADS-B system shall (R2.6) accommodate a means to ensure anonymity whenever pilots elect to operate under flight rules permitting an anonymous mode.

2.1.2.2.1 Call Sign

ADS-B shall (R2.7) be able to convey an aircraft call sign of up to 8 alphanumeric characters in length [6]. For aircraft/vehicles not receiving ATS services and military aircraft the call sign is not required.

Note: The call sign is reported in the Mode-Status (MS) report (§3.4.4 and §3.4.4.4 below).

2.1.2.2.2 Participant Address and Address Qualifier

The ADS-B system design shall (R2.8) include a means (e.g., an address) to (a), correlate all ADS-B messages transmitted from the A/V and (b), differentiate it from other A/Vs in the operational domain.

Those aircraft requesting ATC services may be required in some jurisdictions to use the same 24 bit address for all CNS systems. Aircraft with Mode-S transponders using an ICAO 24 bit address shall (R2.9) use the same 24 bit address for ADS-B. All aircraft/vehicle addresses shall (R2.10) be unique within the applicable operational domain(s).

The ADS-B system design shall (R2.6) accommodate a means to ensure anonymity whenever pilots elect to operate under flight rules permitting an anonymous mode.

Notes

1. *Some flight operations do not require one to fully disclose either the A/V call sign or address. This feature is provided to encourage voluntary equipage and operation of ADS-B by ensuring that ADS-B messages will not be traceable to an aircraft if the operator requires anonymity.*

2. *Mode A transponder codes are not included in the ADS-B message set. Therefore, ground-based surveillance systems may need to correlate ADS-B messages with Mode A transponder codes to facilitate the integration of radar and ADS-B information on the same A/V.*

2.1.2.2.2.1 Participant Address

The Participant Address field shall (R2.xx) be included in all ADS-B reports. This 24-bit field contains either the ICAO 24-bit address assigned to the particular aircraft about which the report is concerned, or another kind of address, as determined by the Address Qualifier field.

2.1.2.2.2.2 Address Qualifier

The Address Qualifier field shall (R2.xx) be included in all ADS-B reports. This field consists of one or more bits and describes whether or not the Address field contains the 24-bit ICAO address of a particular aircraft, or another kind of address.

Notes:

1. *The particular encoding used for the Address Qualifier is not specified in this MASPS, but is left for specification in lower level documents, such as the MOPS for a particular ADS-B data link. Experience in developing the MOPS for several proposed ADS-B data links suggests that 4 bits is sufficient for the Address Qualifier field.*

2. *Surface vehicles for a given airport need to have unique addresses only within range of the airport; vehicle addresses may be reused at other airports.*

3. *A participant's address and address qualifier are included as parts of all reports about that participant.*

2.1.2.2.3 ADS-B Emitter Category

An ADS-B participant's "emitter category" is conveyed in the Mode-Status report (§3.4.4 and §3.4.4.5). The emitter category describes the type of A/V or other AD-B participant. The ADS-B system shall (R2.11) provide for at least the following emitter categories:

- Light (ICAO) - 7,000 kg (15,500 lbs) or less
- Small aircraft – 7,000 kg to 34,000 kg (15,500 lbs to 75,000 lbs)
- Large aircraft – 34,000 kg to 136,000 kg (75,000 lbs to 300,00 lbs)
- High vortex large (aircraft such as B-757)
- Heavy aircraft (ICAO) - 136,000 kg (300,000 lbs) or more
- Highly maneuverable (> 5g acceleration capability) and high speed (> 400 knots cruise)
- Rotorcraft
- Glider/Sailplane
- Lighter-than-air
- Unmanned Aerial vehicle
- Space/Trans-atmospheric vehicle
- Ultralight / Hang glider / Paraglider
- Parachutist/Skydiver
- Surface Vehicle - emergency vehicle
- Surface Vehicle - service vehicle
- Point obstacle (includes tethered balloons)
- Cluster obstacle
- Line obstacle

Notes:

1. *ICAO Medium aircraft – 7,000 to 136,000 kg (15,500 to 300,000 lbs) can be represented as either small or large aircraft as defined above.*

2. *Obstacles can be either fixed or movable. Movable obstacles would require a position source.*

3. *Weights given for determining participant categories are maximum gross weights, not operating weights.*

4. *The following category code assignments should be considered for aircraft operating in the United States national air space (NAS).*

Light :	*Less than 7,000 kg (15,500 lb)*
Small:	*³ 15,500 and < 41,000 lb*
Large:	*³ 41,000 lb and < 255,000 lb and not in "High Vortex Large" category*
High Vortex Large:	*Certain other aircraft, including B-757*
Heavy:	*³ 255,000 lb*

2.1.2.3 A/V Length and Width Codes

The A/V length and width codes describe the amount of space that an aircraft or ground vehicle occupies and are components of the Mode-Status report (§3.4.4, §3.4.4.6). The aircraft length and width codes are not required to be transmitted by all ADS-B participants all of the time. However, they *are* required to be transmitted by aircraft above a certain size, at least while those aircraft are in the airport surface movement area.

2.1.2.4 Position

Position information shall (R2.14) be transmitted in a form that can be translated, without loss of accuracy and integrity, to latitude, longitude, geometric height, and barometric pressure altitude. The position report elements may be further categorized as geometric position and barometric altitude.

- The geometric position report elements are horizontal position (latitude and longitude), and geometric height. All geometric position elements shall (R2.15) be referenced to the WGS-84 ellipsoid.
- Barometric pressure altitude shall (R2.18) be reported referenced to standard temperature and pressure.

2.1.2.5 ADS-B Position Reference Point

The ADS-B position reference point is the position on an A/V that is broadcast in ADS-B messages as the nominal position of that A/V. For aircraft and ground vehicles, this position is normally the center of the smallest rectangle that contains all the extremities of A/V and is oriented parallel to the longitudinal axis of the A/V. Figure 2.1.2.5 illustrates the location of the ADS-B reference point.

If the length code part of an aircraft's size code (Table 3.4.4.6 in §3.4.4.6 below) is 1 or greater and its NAC_P code (§2.1.2.13 above) is 10 or greater, then the horizontal position sent by that aircraft's ADS-B transmitting subsystem shall (R2.xx) be the position of the ADS-B position reference point.

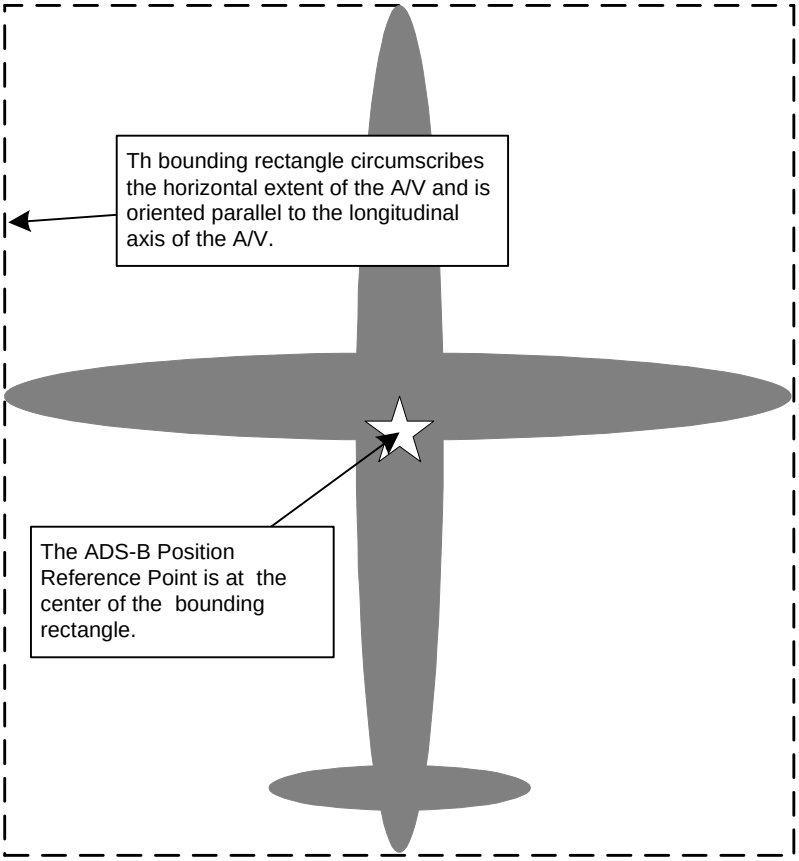

Figure 2.1.2.5: ADS-B Position Reference Point

Note: The accuracy of the location of the ADS-B position reference point with respect to the body of the A/V should be included when determining the NAC_P code to be transmitted from a transmitting ADS-B participant.

2.1.2.6 Altitude

Both barometric pressure altitude and geometric altitude (height above the WGS-84 ellipsoid) shall (R2.17) be reported, if available to the transmitting ADS-B subsystem. Some applications may have to compensate if only one source is available. However, when an A/V is operating on the airport surface, the altitude is not required to be reported, provided that the A/V indicates that it is on the surface.

Altitude shall (R2.19) be provided with a range from -1,000 ft up to +100,000 ft. For fixed or movable obstacles, the altitude of the highest point should be reported.

Note: In this context, a "movable obstacle" means an obstacle that can change its position, but only slowly, so that its horizontal velocity may be ignored.

2.1.2.6.1 Pressure Altitude

Barometric pressure altitude is the reference for vertical separation within the NAS and ICAO airspace. Barometric pressure altitude is reported referenced to standard temperature and pressure.

Pressure altitude, which is currently reported by aircraft in SSR Mode C and Mode S, will also be transmitted in ADS-B messages and reported to client applications in SV reports. The pressure altitude reported shall (R3.34) be derived from the same source as the pressure altitude reported in Mode C and Mode S for aircraft with both transponder and ADS-B.

2.1.2.6.2 Geometric Altitude

Geometric altitude is defined as the shortest distance from the current aircraft position to the surface of the WGS-84 ellipsoid. It is positive for positions above the WGS-84 ellipsoid surface, and negative for positions below that surface.

2.1.2.7 Horizontal Velocity

There are two kinds of velocity information:

- "Ground-referenced" or "geometric" velocity is the velocity of an A/V relative to the earth, or to a coordinate system (such as WGS-84) that is fixed with respect to the earth. Ground-referenced velocity is communicated in the SV report (§3.4.3, §3.4.3.8 and §3.4.3.16).
- Air-referenced velocity is the velocity of an aircraft relative to the air mass through which it is moving. Airspeed, the *magnitude* of the air-referenced velocity vector, is communicated in the ARV report, §3.4.7. The ARV report also includes heading (§2.1.2.9), which is used in that report as an estimate of the *direction* of the air-referenced velocity vector.

Transmitting A/Vs that are not fixed or movable obstacles shall (R2.20) provide ground-referenced geometric horizontal velocity.

ADS-B geometric velocity information shall (R2.21) be referenced to WGS-84 [7].

2.1.2.8 Vertical Rate

Transmitting A/Vs that are not fixed or movable obstacles and that are not known to be on the airport surface shall (R2.xx) provide vertical rate.

Note 1: In this context, a "movable obstacle" means an obstacle that can change its position, but only slowly, so that its horizontal velocity may be ignored.

Vertical Rate shall (R2.23) be designated as climbing or descending and shall (R2.xx) be reported up to 32,000 feet per minute (fpm). Barometric altitude rate is defined as the current rate of change of barometric altitude. Likewise, geometric altitude rate is the rate of change of geometric altitude. At least one of the two types of vertical rate (barometric and geometric) shall (R2.xx) be reported.

If only one of these two types of vertical rate is reported, it shall (R2.xx) be obtained from the best available source of vertical rate information. If differentially corrected GPS (WAAS, LAAS, or other) is available, geometric altitude rate as derived from the GPS source should be transmitted. If differentially corrected GPS is not available, but inertial augmented barometric altitude rate is available, inertial augmented barometric altitude rate will be the preferred source of altitude rate information.

Note 2: Future versions of this MASPS are expected to include requirements on the accuracy and latency of barometric altitude rate.

Note 3: Vertical rate is reported in the SV report (§3.4.3) below.

2.1.2.9 Heading

Heading indicates the orientation of an A/V, that is, the direction in which the nose of the aircraft is pointing. Heading is described as an angle measured clockwise from true north or magnetic north. The heading reference direction (true north or magnetic north) is conveyed in the Mode-Status report (§3.4.4).

Heading occurs not only in the SV report (§3.4.3) for participants on the airport surface, but also in the ARV report (§3.4.7) for airborne participants.

2.1.2.10 Capability Class (CC) Codes

Capability class codes are used to indicate the capability of a participant to support engagement in various operations. Known specific capability class codes are listed below. However, this is not an exhaustive set and provision should be made for future expansion of available class codes, including appropriate combinations thereof.

- CDTI based traffic display capability (§3.4.4.9.1)
- TCAS/ACAS installed and operational (§3.4.4.9.2)
- Service Level of the transmitting A/V (§3.4.4.9.3)
- ARV capability (§3.4.4.9.4)
- TS report capability (§3.4.4.9.5)
- TC report capability level (§3.4.4.9.6)
- Other capabilities, to be defined in later versions of this MASPS

Note: Capability Class (CC) codes are conveyed in the MS report (§3.4.4 below).

2.1.2.11 Operational Mode (OM) Codes

Operational Mode (OM) codes are used to indicate the current operational mode of transmitting ADS-B participants. Specific operational mode codes are listed below. However, this is not an exhaustive set and provision should be made for future expansion of available OM codes, including appropriate combinations thereof.

- TCAS/ACAS resolution advisory active (§3.4.4.10.1).
- IDENT switch activated flag (§3.4.4.10.2)
- Using ATC services (§3.4.4.10.3)
- Other operational modes, to be defined in later versions of this MASPS.

2.1.2.12 Navigation Integrity Category

The Navigation Integrity Category (NIC) is reported so that surveillance applications may determine whether the reported position has an acceptable level of integrity for the intended use. The NIC parameter described in this subsection is intimately associated with the SIL (Surveillance Integrity Level) parameter described in §2.1.2.15 below. The NIC parameter specifies an integrity containment radius, R_C. The SIL parameter specifies the probability of the true position lying outside that containment radius without alerting, including the effects of the airborne equipment condition, which airborne equipment is in use, and which external signals are used.

Note: "NIC" and "NAC_P" as used in the current version (DO-242A) of this MASPS replace the earlier term, "NUC_P", used in the first edition (DO-242) of this MASPS.

The Navigation Integrity Category is reported in the State Vector (SV) report (§3.4.3 below).

Table 2.1.2.12 defines the navigation integrity categories that transmitting ADS-B participants shall (R2.xxx) use to describe the integrity containment radius, R_C, associated with the horizontal position information in ADS-B messages from those participants.

Table 2.1.2.12: Navigation Integrity Categories (NIC).

NIC (Notes 1, 2)	Horizontal and Vertical Containment Bounds	Comment	Notes
0	$R_C \geq 37.04$ km (20 NM)	Unknown Integrity	
1	$R_C < 37.04$ km (20 NM)	RNP-10 containment radius	6
2	$R_C < 14.816$ km (8 NM)	RNP-4 containment radius	3, 6
3	$R_C < 7.408$ km (4 NM)	RNP-2 containment radius	6
4	$R_C < 3.704$ km (2 NM)	RNP-1 containment radius	6
5	$R_C < 1852$ m (1 NM)	RNP-0.5 containment radius	6
6	$R_C < 1111.2$ m (0.6 NM)	RNP-0.3 containment radius	6
7	$R_C < 370.4$ m (0.2 NM)	RNP-0.1 containment radius	6
8	$R_C < 185.2$ m (0.1 NM)	RNP-0.05 containment radius	6
9	$R_C < 75$ m and VPL < [112 m]	e.g., WAAS HPL, VPL	4, 5
10	$R_C < 25$ m and VPL < [37.5 m]	e.g., WAAS HPL, VPL	4, 5
11	RC < 7.5 m and VPL < [11 m]	e.g., LAAS HPL, VPL	4, 5

Notes for Table 2.1.2.12:

1. *NIC is reported by an aircraft because there will not be a uniform level of navigation equipage among all users. Although GNSS is intended to be the primary source of navigation data used to report ADS-B horizontal position, it is anticipated that during initial uses of ADS-B or during temporary GNSS outages an alternate source of navigation data may be used by the transmitting A/V for ADS-B position information. The integration of alternate navigation sources is a function that must be performed by a navigation set that is certified to use multiple sources, which then is responsible for supplying the corresponding integrity containment radius (e.g.., HPL). It is important to point out that this is not a function that can be performed by the ADS-B equipment.*

2. *"NIC" in this column corresponds to "NUC_P" of Table 2-1(a) in the first version of this MASPS, DO-242, dated February 19, 1998.*

3. *The containment radius for NIC = 2 has been changed (from the corresponding radius for NUC_P = 2 in the first edition of this MASPS) so as to correspond to the RNP-4 RNAV limit of DO-236A, rather than the RNP-5 limit of the earlier DO-236. This is because RNP-5 is not a recognized ICAO standard RNP value.*

4. *HPL may be used to represent RC for GNSS sensors.*

5. *If geometric altitude is not being reported than the VPL tests are not assessed.*

6. *RNP containment integrity refers to total system error containment including sources other than sensor error, where as horizontal containment for NIC only refers to sensor position error containment.*

It is recommended that the coded representations of NIC should be such that:

(a) Equipment that conforms to the current version of this MASPS ("version 1" equipment) will recognize the equivalent NUC_P codes from the first edition of this MASPS, and

(b) Equipment that conforms to the initial, DO-242, edition of this MASPS ("version 0" equipment) will treat the coded representations of NIC coming from version 1 equipment as if they were the corresponding "NUC_P" values from the initial, DO-242, version of this MASPS.

2.1.2.13 Navigation Accuracy Category for Position (NAC_P)

The Navigation Accuracy Category for Position (NAC_P) is reported so that surveillance applications may determine whether the reported position has an acceptable level of accuracy for the intended use.

Table 2.1.2.13 defines the navigation accuracy categories that shall (R2.xxx) be used to describe the accuracy of positional information in ADS-B messages from transmitting ADS-B participants.

Notes:

1. *"NIC" and "NAC_P" as used in this MASPS replace the earlier term, "NUC_P", used in the initial, DO-242, edition of this MASPS .*

2. *The Estimated Position Uncertainty (EPU) used in Table 2.1.2.13 is a 95% accuracy bound on horizontal position. EPU is defined as the radius of a circle, centered on the reported position, such that the probability of the actual position being outside the circle is 0.05. When reported by a GPS or GNSS system, EPU is commonly called HFOM (Horizontal Figure of Merit).*

3. *Likewise, Vertical Estimated Position Uncertainty (VEPU) is a 95% accuracy limit on the vertical position. VEPU is defined as a vertical position limit, such that the probability of the actual vertical position differing from the reported vertical position by more than that limit is 0.05. When reported by a GPS or GNSS system, VEPU is commonly called VFOM (Vertical Figure of Merit).*

4. *The EPU limit for NAC_P = 2 has been changed (from the corresponding limit for NUC_P = 2 in the first edition of this MASPS) so as to correspond to the RNP-4 RNAV limit of DO-236A, rather than the RNP-5 limit of the earlier DO-236. This is because RNP-5 is not an ICAO standard RNP value.*

Table 2.1.2.13: Navigation Accuracy Categories for Position (NAC_P).

NAC_P	95% Horizontal and Vertical Accuracy Bounds (EPU and VEPU)	Comment	Notes
0	EPU ≥ 18.52 km (10 NM)	Unknown accuracy	
1	EPU < 18.52 km (10 NM)	RNP-10 accuracy	1
2	EPU < 7.408 km (4 NM)	RNP-4 accuracy	1
3	EPU < 3.704 km (2 NM)	RNP-2 accuracy	1
4	EPU < 1852 m (1NM)	RNP-1 accuracy	1
5	EPU < 926 m (0.5 NM)	RNP-0.5 accuracy	1
6	EPU < 555.6 m (0.3 NM)	RNP-0.3 accuracy	1
7	EPU < 185.2 m (0.1 NM)	RNP-0.1 accuracy	1
8	EPU < 92.6 m (0.05 NM)	e.g., GPS (with SA)	1
9	EPU < 30 m and VEPU < 45 m	e.g., GPS (SA off)	2
10	EPU < 10 m and VEPU < 15 m	e.g., WAAS	2
11	EPU < 3 m and VEPU < 4 m	e.g., LAAS	2

Notes for Table 2.1.2.13:

1. *RNP accuracy includes error sources other than sensor error, whereas horizontal error for NAC_P only refers to horizontal position error uncertainty.*

2. *If geometric altitude is not being reported than the VEPU tests are not assessed.*

2.1.2.14 Navigation Accuracy Category for Velocity (NAC_V)

The velocity accuracy category of the least accurate velocity component being supplied by the reporting A/V's source of velocity data shall (R2.27) be as indicated in Table 2.1.2.14.

Notes:

1. *NAC_V is another name for the parameter that was called NUC_R in the initial (DO-242) version of this MASPS.*

2. *Navigation sources, such as GNSS and inertial navigation systems, provide a direct measure of velocity which can be significantly better than that which could be obtained by position differences.*

Table 2.1.2.14: Navigation Accuracy Categories for Velocity (NAC_V).

NAC_V	Horizontal Velocity Error (95%)	Vertical Geometric Velocity Error (95%)
0	Unknown or ≥ 10 m/s	Unknown or ≥ 50 feet (15.24 m) per second
1	< 10 m/s	< 50 feet (15.24 m) per second
2	< 3 m/s	< 15 feet (4.57 m) per second
3	< 1 m/s	< 5 feet (1.52 m) per second
4	< 0.3 m/s	< 1.5 feet (0.46 m) per second

Notes for Table 2.1.2.14:

1. *When an inertial navigation system is used as the source of velocity information, error in velocity with respect to the earth (or to the WGS-84 ellipsoid used to represent the earth) is reflected in the NACV value.*

2. *When any component of velocity is flagged as not available the value of NAC_V will apply to the other components that are supplied.*

2.1.2.15 Surveillance Integrity Level (SIL)

The Surveillance Integrity Level (SIL) defines the probability of the integrity containment radius used in the NIC parameter (§2.1.2.12 above) being exceeded, without alerting, including the effects of the airborne equipment condition, which airborne equipment is in use, and which external signals are used by the navigation source. The Surveillance Integrity Limit encoding shall (R2.xxx) be as indicated in Table 2.1.2.15.

Note: It is assumed that SIL is a static (unchanging) value that depends on the position sensor being used. Thus, for example, if an ADS-B participant reports a NIC code of 0 because four or fewer satellites are available for a GPS fix, there would be no need to change the SIL code until a different navigation source were selected for the positions being reported in the SV report. <<Thanks to Tom Mosher for posing this question in an e-mail to Jim Maynard.>>

Table 2.1.2.15: Surveillance Integrity Level (SIL) Encoding.

SIL	Probability of Exceeding the R_C Integrity Containment Radius Without Detection	Comment
0	Unknown	"No Hazard Level" Navigation Source
1	1×10^{-3} per flight hour or per operation	"Minor Hazard Level" Navigation Source
2	1×10^{-5} per flight hour or per operation	"Major Hazard Level" Navigation Source
3	1×10^{-7} per flight hour or per operation	"Severe Major Hazard Level" Navigation Source

2.1.2.16 Barometric Altitude Quality Code (BAQ)

The Barometric Altitude Quality Code, BAQ, is a 2-bit field which shall be ZERO for equipment that conforms to this version (DO-242A) of the ADS-B MASPS.

Notes:

1. *Non-zero values of the barometric altitude accuracy code will be defined in future versions of this MASPS. One proposed encoding is given in Table 2.1.2.16; however, it is not certain that this encoding will be the one specified in future versions of this MASPS.*

Table 2.1.2.16: Possible Future Encoding for Barometric Altitude Quality.

BAQ	*Meaning*
0	*Barometric altitude not certified for IFR use*
1	*Barometric altitude with 100 feet resolution*
2	*Barometric altitude with 25 feet resolution*
3	*Barometric altitude meets RVSM requirements*

2. *BAQ, the barometric altitude accuracy code, is reported in the Mode-Status report (§3.4.4.14 below).*

2.1.2.17 Barometric Altitude Integrity Code (NIC_{baro})

The Barometric Altitude Integrity Code, NIC_{baro}, is a one-bit flag that indicates whether or not the barometric pressure altitude provided in the State Vector Report has been cross-checked against another source of pressure altitude.

Note: NIC_{baro}, the barometric altitude integrity code, is reported in the Mode-Status report (§3.4.4).

2.1.2.18 Emergency/Priority Status

The ADS-B system shall (R2.28) be capable of supporting broadcast of emergency and priority status. Emergency/priority status is reported in the MS report (§3.4.4 and §3.4.4.8 below).

2.1.2.19 Intent Information

Note: Persons familiar with the first (DO-242) edition of this MASPS are urged to study the definitions presented here. The terminology has been refined – and changed – from that used in the first edition of the MASPS.

The reason for considering broadcast of intent information in ADS-B systems is to extend the domain of predictability of aircraft trajectories beyond short-term extrapolations using current aircraft position and velocity states. Many applications of ADS-B currently under consideration could require intent information to extend look-ahead time for trajectory predictions beyond the current flight segment, or as a means of enhancing integrity of extrapolated path predictions. Proposed air-air applications of intent information include airborne separation planning where more than a few minutes look-ahead time is desirable for conflict detection and conflict prevention, and conflict resolution, where broadcast of intended resolution maneuvers may be important for situation awareness of all nearby equipped aircraft. ADS-B intent information is also proposed to enable advanced air-ground applications such as sequencing and merging of terminal area flow streams, conformance monitoring, and use of precision trajectory separation concepts for aircraft arrival and departure flows in congested airspace.

Short-term intent provides information on the current horizontal and vertical targets for the active flight segment. These targets reflect the current path and automation states being used for aircraft guidance and control. Primary short-term intent elements include target altitude and target heading or track angle. Long-term intent provides strategic path information, consisting of trajectory change points and their connecting flight segments. While short-term intent is available in almost all operational flight modes, four dimensional long-term intent is only available when equipped aircraft are using sophisticated FMS and area navigation (RNAV) systems. Intent information over ADS-B is supported by two on-condition reports: Target State (TS) report (§3.4.8) and Trajectory Change (TC) Report (§3.4.9). These reports correspond to short and long-term intent, respectively. Appendix N provides a detailed discussion of intent availability related to aircraft control state and equipment.

Intent information provided in TS and TC reports reflects aircraft states and targets programmed into the transmitting aircraft's automation system.

Note: When broadcasting intent, the ADS-B transmitting subsystem should not infer a pilot's future actions. Some intent information communicated may not reflect the aircraft's actual intended trajectory until the pilot takes further actions.

This MASPS incorporates intent information elements that are sufficiently understood and developed, with strong preference to information available from many current aircraft. Intent elements not currently available on avionics data buses are provided in DO-242A in cases where they can likely be derived from current avionics systems and when needed to support international intent applications.

Note: Some data elements in the TS report (§3.4.8) and TC report (§3.4.9) formats are indicated in this MASPS as "reserved for" use in future versions of this MASPS. These "reserved for" data elements are expected to be of operational value for future applications, but presently lack sufficient development. Further development and validation of these concepts are planned for future MASPS revisions.

This MASPS defines requirements for the Target State (TS) report and first Trajectory Change (TC+0) report. Requirements for additional TC reports beyond the TC+0 report are deferred for later MASPS revisions, pending the results of ongoing studies. Current work on management of multiple TC reports is documented in Appendix N.

Detailed intent element requirements and conditions for broadcasting TS and TC Report information, are described in §3.4.8 and §3.4.9, respectively. Required update rates and minimum acquisition ranges are specified in §3.3.3.1.4.

2.1.2.19.1 Short Term Intent

Short-term intent is reported in the Target State (TS) report (§3.4.8) and consists primarily of the target altitude (or appropriate substitutes for target altitude, see §3.4.8.13) and target heading or target track angle for the active flight segment.

- The *target altitude* is the aircraft's next intended level flight altitude if in a climb or descent or its current intended altitude if commanded to hold altitude.
- The *target heading* is the aircraft's intended heading after turn completion or its current intended heading if in straight flight.
- The *target track angle* is the aircraft's intended track angle over the ground after turn completion or its current intended track angle if in straight flight.

Target track angle is only provided if the aircraft is being controlled to a ground referenced track angle, whereas target heading is provided when being controlled to a air-reference heading.

These parameters represent the aircraft's tactical intent and are often selected directly by the pilot through an autopilot control panel. Examples include selected altitude for limiting a descent or climb transition and selected heading when following vectors issued by air traffic control. Target altitude and target heading or track angle can also refer to the current intended targets flown by an autopilot in more automated modes, such as those supported by RNAV and FMS. In this case, the target track angle may be the track to the next waypoint or the outbound track angles following a turn maneuver.

The TS report provides a way for aircraft equipped with less sophisticated automation systems or flying in tactical flight modes to exchange short-term intent information. This information can be used for separation assurance and clearance verification applications.

For equipage classes A2 and A3, the ADS-B system shall (R2.xx) provide the capability to transmit and receive messages in support of the TS report. TS report capability is optional for equipage class A1.

Short term horizontal intent is conveyed in the Target State (TS) report (§3.4.8) and includes the following report elements:

- Target Heading or Track Angle (§3.4.8.5)
- Target Heading / Target Track Indicator (§3.4.8.6)
- Horizontal Target Source Indicator (§3.4.8.4
- Horizontal Mode Indicator (§3.4.8.8)

Short term vertical intent is conveyed in the Target State (TS) report (§3.4.8) and includes the following report elements:

- Target Altitude (§3.4.8.11)
- Target Altitude Type (§3.4.8.12)
- Target Altitude Capability (§3.4.8.13)
- Vertical Target Source Indicator (§3.4.8.10)
- Vertical Mode Indicator (§3.4.8.14)

2.1.2.19.2 Long-Term Intent

Long-term intent represents information on the aircraft trajectory beyond the current flight segment. It is likely to come from flight planning contained in FMS or RNAV systems. Long-term intent includes information on Trajectory Change Points (TCPs) and their connecting flight segments. Communicating intent information helps a receiving participant to facilitate path re-generation, data confidence assessment, and conformance monitoring for targets of interest. This strategic intent information is expected to be beneficial for applications such as flight path deconfliction and traffic flow management.

While short-term intent is available in almost all operational flight modes, four dimensional long-term intent is only available when equipped aircraft are using sophisticated FMS and area navigation (RNAV) systems.

A *trajectory change point (TCP)* is a point where an anticipated change in the aircraft's velocity vector will cause an intended change in trajectory. The change in trajectory may be either a change in path or a change in speed. The location of a full three-dimensional TCP *may not always be known* to the transmitting ADS-B subsystem, and the information defining the locus of possible change points for a TCP may be conveyed in *more than just a single* report. For instance, information about a TCP may be conveyed in the most recent SV and TS reports, or in the most recent TS and TC+0 reports, or in a single TC+0 or TC+n report.

Note: The first edition (DO-242) of this MASPS defined trajectory change points differently, as a particular kind of on-condition report that conveys information about where the aircraft trajectory is intended to change. In this current (DO-242A) MASPS, the terms SV, TS, and TC report are reserved for the various types of reports that may be used to convey TCP information; but the term TCP is reserved for a 3-D location in space where the aircraft trajectory is intended to change.

The *current TCP* is that TCP to which the aircraft is currently being controlled. This definition includes cases where flight segment changes do not occur at a known 3D point.

For example, figure 2.1.2.19.2 (a) shows an aircraft descending toward a target altitude. In this case, the current TCP – the point where the aircraft's trajectory is expected to change – is communicated using elements from the SV report (§3.4.3) and the Target State Report (§3.4.8). The actual latitude and longitude of the current TCP may not be known precisely, but an estimate can be derived from information that the transmitting ADS-B participant broadcasts.

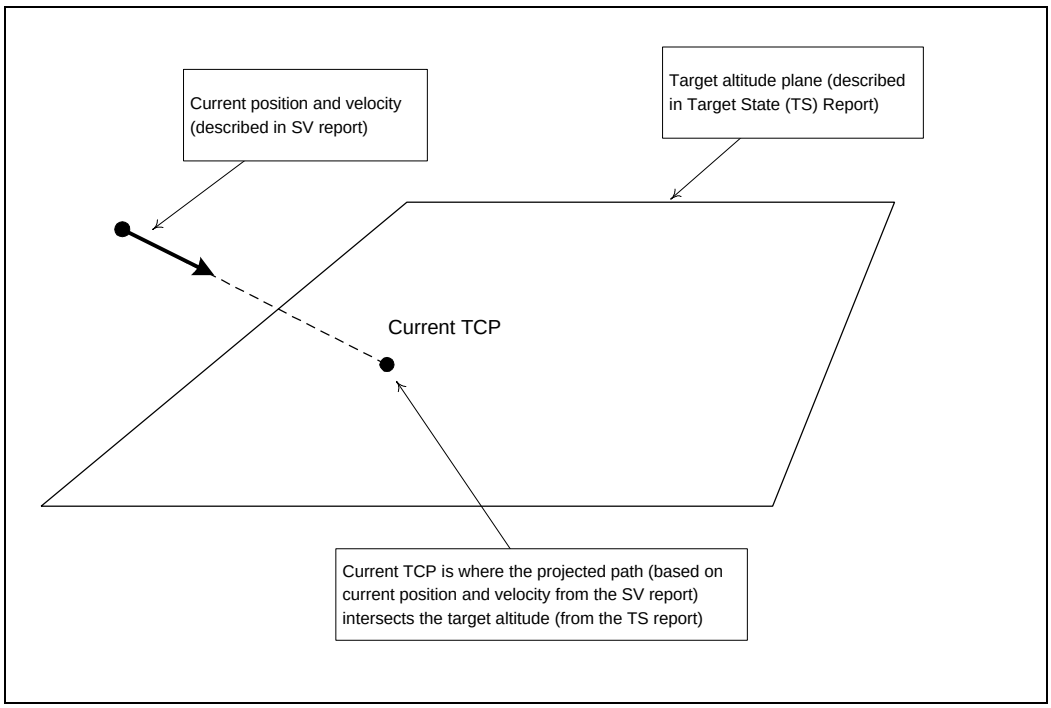

Figure 2.1.2.19.2 (a): Current TCP Information, As Conveyed With SV and TS Reports.

As another example, consider the case of a flight plan defined by several FMS (Flight Management System) waypoints. Our transmitting ADS-B participant is not yet flying along that flight plan, but is in the process of joining the first leg of the flight plan. Figure 2.1.2.19.2 (b): shows the situation. This example is for an aircraft in which the FMS does not provide the current TCP.

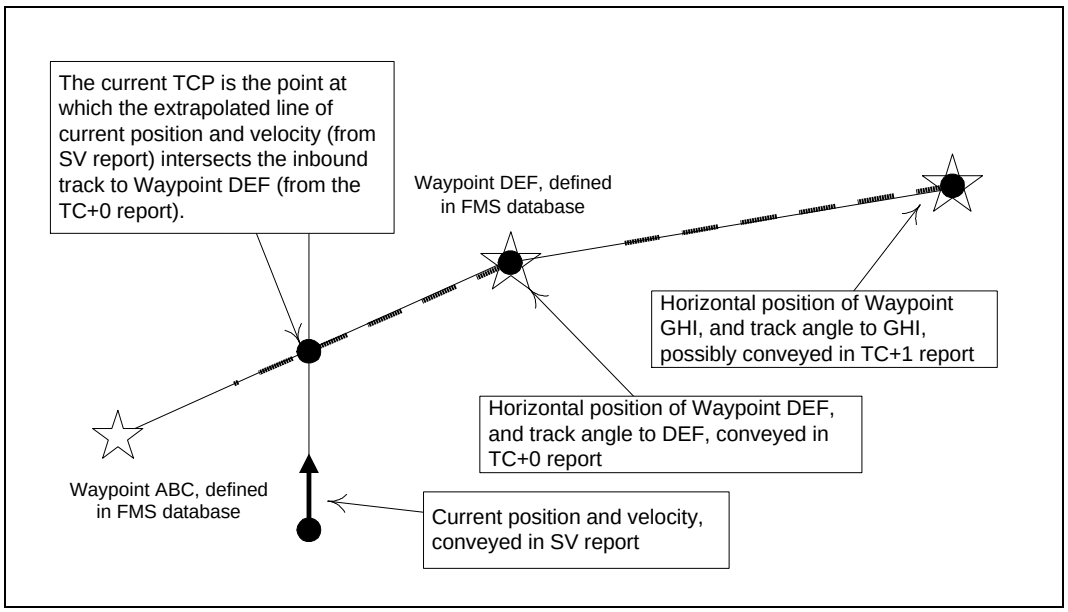

Figure 2.1.2.19.2 (b): Current TCP, As Conveyed With SV and TC+0 Reports.

Note: The goal in defining the various report types (e.g., SV, TS, and TC reports) in this MASPS was to minimize the amount of information that must be broadcast to describe an ADS-B participant's intentions with suitable accuracy and integrity for intended applications.

Thus, in the example of Figure 2.1.2.19.2 (b), the position of waypoint ABC in the flight plan may be stored in the transmitting participant's FMS and communicated to the transmitting ADS-B subsystem, but that position is not transmitted over the air in ADS-B messages; nor is it delivered to client applications on board receiving aircraft in ADS-B reports. Instead, the message generation function at the transmitting ADS-B participant is expected to infer the track angle along which the aircraft intends to approach waypoint DEF. The track angle to DEF and the position of DEF are then conveyed in a TC+0 report for waypoint DEF. The current position and velocity of the transmitting aircraft are conveyed in a SV report. The client application at the receiving aircraft could infer the anticipated location of the next point at which the transmitting aircraft's trajectory is intended to change (that is, the current TCP) from the information it receives in the SV and TC+0 reports.

TC report elements are designed to reflect the capabilities of existing and future aircraft avionics. TC report fields are filled based on information availability aboard the transmitting aircraft and the horizontal and vertical TC types. Example TC types include 2D routing changes, the start and end points of a specified turn transition, FMS predicted Top of Climb and Top of Descent points, and selected altitude from an autopilot control panel when currently in climb or descent transitions. All broadcast trajectory change information must correspond to a supported TC type. Additional TC types, such as waypoint altitude constraints, may be incorporated into future MASPS revisions.

For equipage class A2, the ADS-B system shall (R2.xx) provide the capability to transmit and receive messages in support of one TC (TC+0) report. For equipage class A3, the ADS-B system shall (R2.xx) provide the capability to transmit and receive messages in support of multiple TC reports.

Long-term intent is conveyed in the Trajectory Change Report (TCR, paragraph3.4.9) and contains the following report elements:

- Participant Address (sub-paragraph 2.1.2.3.1)
- Address Qualifier (sub-paragraph 2.1.2.3.2)
- Time of Applicability (sub-paragraph 2.1.2.1)
- TCR Cycle Number (sub-paragraph 3.4.8.4)
- Time to Go (sub-paragraph 3.4.8.6)
- Horizontal Data Available (sub-paragraph 3.4.8.7.1)
- Horizontal TCP Type (sub-paragraph 3.4.8.7.2)
- TCP Latitude (sub-paragraph 3.4.8.7.3)
- TCP Longitude (sub-paragraph 3.4.8.7.4)
- Turn Radius (sub-paragraph 3.4.8.7.5)
- Track to TCP (sub-paragraph 3.4.8.7.6)
- Track from TCP (§3.4.8.7.7)
- Horizontal Command/Planned (sub-paragraph 3.4.8.7.9)
- Vertical Data Available (sub-paragraph 3.4.8.8.1)
- Vertical TCP Type (sub-paragraph 3.4.8.8.2)
- TCP Altitude (sub-paragraph 3.4.8.8.3)
- TCP Altitude Type (sub-paragraph 3.4.8.8.4)
- Vertical Command/Planned (§3.4.8.8.8)

2.1.2.20 Other Information

2.2 System Performance – Standard Operational Conditions

3 ADS-B System definition and Functional Requirements

3.1 System Scope and Definition of Terms

3.2 ADS-B System Description

3.2.1 Context Level Description

3.2.2 Participant Architecture Examples

3.2.3 Equipage Classifications

3.2.3.1 Interactive Aircraft/Vehicle ADS-B Subsystems (Class A)

3.2.3.2 Broadcast-Only Subsystems (Class B)

3.2.3.3 Ground Receive-Only Subsystem (Class C)

3.3 System Requirements

3.3.1 Surveillance Coverage

3.3.2 Information Exchange Requirements By Equipage Class

3.3.3 ADS-B Data Exchange Requirements

3.3.3.1 Report Accuracy, Update Period, and Acquisition Range

The subparagraphs below specify the report accuracy, update period, and acquisition range requirements for state vector, modes status, and specific on-condition reports. For each of these subparagraphs, report acquisition shall (R3.12) be considered accomplished when all report elements required for an operational scenario have been received by an ADS-B participant. In order to meet these requirements, the receiving participant must begin receiving messages at some range outside the minimum range for a given application. Appendix L illustrates examples of expected acquisition time for state vector, mode-status, and on-condition reports as a function of message period and probability of receipt. Appendix L also treats the necessary acquisition time for segmented state vector messages.

3.3.3.1.1 State Vector Report Acquisition, Update Interval, and Acquisition Range

State vector (SV) report accuracy, update period and acquisition range requirements are derived from the sample scenarios of Chapter 2, and are specified in Table 3-4(a). The state vector report shall (R3.9) meet the update period and 99 percentile update period requirements for each operational range listed. The rationale for these values is given in Appendix J. The formulation in Appendix J examines the loss of alert time resulting from data inaccuracies, report update interval, and probability of reception. The scope of the analysis was not sufficient to guarantee that the specific operations considered will be supported. Several range values are specified in the table because the alert time requirements are more demanding for short range than they are for surveillance of targets at longer ranges. The first value is based on minimum range requirements. Beyond this range, update period and/or receive probability may be relaxed for each sample scenario, as given by the other values.

For each of the scenarios included in Table 3-4(a), the state vectors from at least 95% of the observable user population (radio line-of-sight) supporting that application shall (R3.10) be acquired and achieve the time and probability update requirements specified for the operational ranges. For the remaining 5% of the user population that has not been acquired at this specified range, they will be acquired with high probability (99%) within the coast interval specified in Table 3-4(a). The state vector report is constantly changing and is important to all applications, including the safety critical ones. Algorithms designed to use the state vector reports will assume that the information provided is correct. (Some applications may even require that the information is validated before using it.)

Table 3-3(a): Interactive Aircraft/Vehicle Equipage Type Operational Capabilities

	Domain ®		Terminal, En-route, Oceanic								Approach		Airport Surface	
Equipage Class –	Data Required to Support Operational Capability		R £10 NM e.g., Conflict Detection, Enhanced visual Acquisition		R £20 NM e.g., Airborne Conflict management, station keeping		R £40 NM e.g., Merging, conflict management, in-trail climb		R £90 NM e.g., Long range conflict management		R £10 NM e.g., AILS, paired approach		R £5 NM e.g., Airport Surface Situation Awareness	
	Transmit	Receive	Sup-port	Per-form	Sup-port	Per-form	Sup-port	Per-form	Sup-port	Per-form	Sup-port	Per-form	Sup-port	Per-form
A0 Minimum R=10 NM	SV MS SC	SV MS SC	Yes	Yes	Yes	No	No	No	No	No	No	No	Yes	Yes
A1 Basic R=20 NM	SV MS SC ARV	SV MS SC ARV	Yes	Yes	Yes	Yes	No	No	No	No	Yes	Yes	Yes	Yes
A2 Enhanced R=40 NM	SV MS SC ARV TS TC+0	SV MS SC ARV TS TC+0	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes
A3 Extended R=90 NM	SV MS SC ARV TS TC+n	SV MS SC ARV TS TC+n	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: *SV= State Vector; MS = Mode-Status; SC = Status Change; ARV = Air=Referenced Velocity; TS = Target State Report; TC+0 = Single Trajectory Change Report capability; TC+n = Multiple TC report capability, n = 1 to TBD*

* *Operation in airspace with high closure rates may require longer range.*

** *Class A2 and A3 users may equip for low visibility taxi following.*

Table 3-3(b): Broadcast and Receive Only Equipage Type Operational Capabilities

	Domain ®		**Terminal, En-route, and** Oceanic / Remote Non-Radar								**Approach**		**Airport Surface**	
Equipage Class	**Data Required to Support Operational Capability**		**R £ 10 NM** e.g., Conflict Detection, Enhanced visual Acquisition		**R £ 20 NM** e.g., Airborne Conflict management, station keeping		**R £ 40 NM** e.g., Merging, conflict management, in-trail climb		**R £ 90 NM** e.g., Long range conflict management		**R £ 10 NM** e.g., AILS, paired approach		**R £ 5 NM** e.g., Airport Surface Situation Awareness	
	Transmit	Receive	Sup-port	Per-form	Sup-port	Per-form	Sup-port	Per-form	Sup-port	Per-form	Sup-port	Per-form	Sup-port	Per-form
B1 Aircraft	SV MS SC	No	Yes	No	Yes	No	No	No	No	No	No	No	Yes	No
B2 Ground Vehicle	SV MS SC	No	Yes	No	Yes	No	No	No	No	No	No	No	Yes	No
B3 Fixed Obstacle	SV MS SC	No	Yes	No	Yes	No	No	No	No	No	No	No	Yes	No
C1 ATS En route & Terminal	No	SV MS SC ARV TS, TC+n	No	Yes	No	Yes	No	Yes	No	Yes	No	No	No	No
C2 Approach & Surface	No	SV MS SC ARV TS, TC+n	No	Yes	No	Yes	No	No	No	No	No	Yes	No	Yes
C3 Flight Following	No	SV MS SC	No	Yes	No	No	No	No	No	No	No	No	No	No

Notes: SV= State Vector; MS = Mode-Status; SC = Status Change; ARV = Air=Referenced Velocity; TS = Target State Report; TC+0 = Single Trajectory Change Report; TC+n = Multiple TC reports, n = 1 to TBD

Required ranges for acquisition shall (R3.13) be as specified in Table 3-4(a): (10 NM for A0, 20 NM for A1, 40 NM for A2, and 90 NM for A3).

Table 3-4(a) shows accuracy values in two ways: one describing the ADS-B report information available to applications, and the other presenting the error budget component allocated to ADS-B degradation of this information. The ADS-B system shall (R3.14) satisfy the error budget requirements specified in the table in order to assure satisfaction of ADS-B report accuracies. Degradation is defined here to mean additional errors imposed by the ADS-B system on position and velocity measurements above the inherent navigation source errors. The errors referred to in this section are specifically due to ADS-B quantization of state vector information, and other effects such as tracker lag. ADS-B timing and latency errors are treated as a separate subject under heading 3.3.3.2. The maximum errors specified in Table 3-4(a) are limited to contributions from the following two error sources:

- Quantization errors. The relationship between the quantization error and the number of bits required in the ADS-B message are described in Appendix G. This discussion also treats the effect of data sampling time uncertainties on report accuracy.
- Errors due to a tracker. The ADS-B system design may include a smoothing filter or tracker as described in Appendix G. If a smoothing filter or tracker is used in the ADS-B design, the quality of the reports shall be sufficient (R3.15) to provide equivalent track accuracy implied in Table 3-4(a) over the period between reports, under target centripetal accelerations of up to 0.5g with aircraft velocities of up to 600 knots. Tracker lag may be considered to be a latency (Section 3.3.3.2).

Table 3-4 (a): SV and MS Accuracy, Update Interval, and Acquisition Range Requirements

Operational Domain ®	**Terminal, En-route, and Oceanic / Remote Non-Radar** –				**Approach** –	**Airport Surface** – (Note 4)
Applicable Range ®	**R £ 10 NM**	**10 NM < R £ 20 NM**	**20 NM < R £ 40 NM**	**40 NM < R £ 90 NM**	**R £ 10 NM**	**(R £ 5 NM)**
Equipage Class ® (Note 13)	**A0-A3 B1-B3**	**A1-A3 B1-B3**	**A2-A3**	**A3**	**A1-A3**	**A0-A3 B1-B3**
Example Applications ®	Airborne Conflict Management (ACM) Enhanced Visual Acquisition	Station Keeping	Merging, Conflict Management, In-Trail Climb	Long Range Conflict Management	AILS, Paired Approach	Surface Situational Awareness
Required SV Acquisition Range	10 NM	20 NM	40 NM (Note 16) (50 NM desired)	90 NM (Notes 3, 11) (120 NM desired)	10 NM	5 NM
Required 95th percentile MS Acquisition Range	10 NM	20 NM	40 NM (Note 16) (50 NM desired)	90 NM (Notes 3, 11) (120 NM desired)	10 NM	5 NM
Required 99th percentile MS Acquisition Range (Notes 14, 15)	8 NM	17 NM	34 NM (Note 16)	76 NM	n/a	n/a
Required SV Nominal Update Interval (95th percentile) (Note 5)	≤ 3 s (3 NM) ≤ 5 s (10 NM) (Note 12)	≤ 5 s (10 NM) (1 s desired, Note 2) ≤ 7 s (20 NM)	≤ 7 s (20 NM) ≤ 12 s (40 NM)	≤ 12 s	≤ 1.5 s (1000 ft runway separation) ≤ 3 s (1 s desired) (2500 ft runway separation)	≤ 1.5 s
Required 99th Percentile SV Received Update Period (Coast Interval)	≤ 6s (3 NM) ≤ 10 s (10 NM) (Note 12)	≤ 10 s (10 NM) ≤ 14 s (20 NM)	≤ 14 s (20 NM) ≤ 24 s (40 NM)	≤ 24 s	≤ 3s (1000 ft runway separation) (1s desired, Note 2) ≤ 7s (2500 ft runway separation)	≤ 3 s
Example Permitted Total SV Errors Required To Support Application (1 sigma, 1D)	σ_{hp} = 200 m σ_{hv} = n/a σ_{vp} = 32 ft σ_{vv} = 1 fps	σ_{hp} = 20 m / 50 m (note 1) σ_{hv} = 0.6/ 0.75 m/s (Note 1) σ_{vp} = 32 ft σ_{vv} = 1 fps	σ_{hp} = 20 / 50 m (note 1) σ_{hv} = 0.3/ 0.75 m/s (Note 1) σ_{vp} = 32 ft σ_{vv} = 1 fps	σ_{hp} = 200 m σ_{hv} = 5 m/s σ_{vp} = 32 ft σ_{vv} = 1 fps	σ_{hp} = 20 m σ_{hv} = 0.3 m/s σ_{vp} = 32 ft σ_{vv} = 1 fps	σ_{hp} = 2.5 m (Note 6) σ_{hv} = 0.3 m/sσ σ_{vp} = n/a σ_{vv} = n/a
Max. error due to ADS-B (1 sigma, 1D) (Note 7)	σ_{hp} = 20 m σ_{hv} = 0.25 m/s (Note 8) σ_{vp} = 30 ft σ_{vv} = 1 fps					σ_{hp} = 2.5 m (Note 6) σ_{hv} = 0.25 m/s σ_{vp} = n/a σ_{vv} = n/a

Definitions for Table 3-4 (a):

s_{hp}: standard deviation of horizontal position error.

s_{hv}: standard deviation of horizontal velocity error.

s_{vp}: standard deviation of vertical position error.

s_{vv}: standard deviation of vertical velocity error.

n/a: not applicable.

Notes for Table 3-4 (a):

1. *The lower number represents the desired accuracy for best operational performance and maximum advantage of ADS-B. The higher number, representative of GPS standard positioning service, represents an acceptable level of ADS-B performance, when combined with barometric altimeter.*

2. *The analysis in Appendix J indicates that a 3-second report received update period for the full state vector will yield improvements in both safety and alert rate relative to TCAS II, which does not measure velocity. Further improvement in these measures can be achieved by providing a one-second report received update rate Further definition of ADS-B based separation and conflict avoidance system(s) may result in refinements to the values in the Table.*

3. *The 90 NM range requirement applies in the forward direction. The required range aft is 40 NM. The required range 90 degrees to port and starboard is 64 NM. (see Appendix H) [The 120 NM desired range applies in the forward direction. The desired range aft is 48 NM. The desired range 90 degrees to port and starboard is 85 NM.]*

4. *Requirements apply to both aircraft and vehicles.*

5. *Supporting analyses for update period and update probability are provided in Appendices J and L.*

6. *The position accuracy requirement for aircraft on the airport surface is stated with respect to the aircraft's ADS-B position reference point (§2.1.2.5).*

7. *This row represents the allowable contribution to total state vector error from ADS-B.*

8. *The requirements on horizontal velocity error (s_{hv},) apply to aircraft speeds of up to 600 knots. Accuracies required for velocities above 600 knots are TBD.*

9. *Specific system parameter requirements in Table 3-4(a) can be waived provided that the system designer shows that the application design goals stated in Appendix J or equivalent system level performance can be achieved.*

10. *Update periods for the SV have been emphasized in determining link related performance requirements in this table. Lower rates for MS are under consideration. These reports should be made available to support the operational capabilities using considerations equivalent to the SV. The requirement should be optimized to ensure that the refresh/update of reports is appropriate for the equipment classes and the operations being supported..*

11. *Air-to-air ranges extending to 90 NM are intended to support the application of Flight Path Deconfliction Planning, Cooperative Separation in Oceanic/Low Density En Route Airspace, as described in Section 2.2.2.4. However, the minimum range may apply even in high interference environments, such as over-flight of high traffic density terminal areas.*

12. *Requirements for applications at ranges less than 10 NM are under development. The 3-second update period is required for aircraft pairs with horizontal separation less than [1.1 NM] and vertical separation less than [1000 feet]. The 3 second update period is also required to support ACM for aircraft pairs within 3 NM lateral separation and 6000 feet vertical separation that are converging at a rate of greater than 500 feet per minute vertically or greater than 6000 feet per minute horizontally. The update rate can be reduced to once per 5 seconds (95%) for aircraft pairs that are not within these geometrical constraints and for applications other than ACM. Requirements for ACM are under development. Requirements for future applications may differ from those stated here.*

13. *Class B1 equipage performance should correspond with the minimum class A transmit characteristics for the operational ranges specified for the columns as discussed in Section 3.3.1.*

14. *These requirements are to be met for essential level applications. As these applications are developed, these requirements may be further refined in terms of more stringent ranges and acquisition probability.*

15. *It is assumed that the population for which these acquisition requirements are to be met are aircraft that have been operating and broadcasting MS reports within radio line of sight at ranges significantly greater than the acquisition range.*

16. *These values are based on the scenario in §2.2.2.3 which assumes a reduced horizontal separation standard of 2 NM. Longer acquisition ranges are necessary for current separation standards.*

3.3.3.1.2 Mode-Status Acquisition, Update Interval, and Acquisition Range

Mode Status (MS) acquisition range requirements are derived from the sample scenarios of Chapter 2, and are specified in Table 3-4(a). For each of the equipage classes included in Table 3-4 (a), the mode status reports from at least 95% of the observable (radio line of sight) population shall (R3.11) be acquired at the specified range. (10 NM for A0, 20 NM for A1, 40 NM for A2, and 90 NM for A3). For the remaining 5% of the user population that has not been acquired at this specified range, they will be acquired with high probability (at least 99%) within the coast interval specified in Table 3-4(a).

A change in the value of those MS elements specified in Table 3.4.4, will trigger an on-condition Status Change (SC) report (§3.4.6).

3.3.3.1.3 Air Referenced Velocity Acquisition, Update Interval, and Acquisition Range

Air referenced velocity (ARV) update periods and acquisition range requirements are summarized in Table 3-4(b). These requirements are specified in terms of acquisition range and required update interval to be achieved by at least 95% of the observable user population (radio line of sight) supporting ARV on-condition reports within the specified acquisition range or time interval. For the remaining 5% of the user population that has not been acquired at this specified range, they will be acquired with high probability (99%) within the coast interval specified in Table 3-4(a).

Table 3-4(b) Summary of Air Referenced Velocity Report Update Requirements

Operational Domain ®	**Terminal, En-route, and Oceanic / Remote Non-Radar –**			
Applicable Range ®	**R £ 10 NM**	**10 NM < R £ 20 NM**	**20 NM < R £ 40 NM**	**40 NM < R £ 90 NM**
Equipage Class ®	A1 required	A1 required	A2 required	A3 required
ARV Acquisition Range		20 NM	40 NM)	90 NM
ARV Nominal Update Period (95%) when ground referenced velocity data not available	5 s	7 s	12 s	12 s

The Air Referenced Velocity (ARV) report must be broadcasted under the conditions defined in §3.4.7.1.

Note: If the ARV report is being transmitted under other conditions than those which require its update as specified in §3.4.7.1, acquisition ranges and update periods do not have to meet the above requirements.

When the ARV report is required as defined in section §3.4.7.1:

a. The ARV report's nominal update period shall (R3.xx) be 5 seconds for A1, A2, and A3 equipment at ranges of 10 NM and closer.

b. The ARV report's nominal update period shall (R3.xx) be 7 seconds for A1, A2, and A3 equipment at ranges greater than 10 NM and less than or equal to 20 NM.

c. The ARV report's nominal update period shall (R3.xx) be 12 seconds for A2 equipment at ranges greater than 20 NM and less than or equal to 40 NM.

d. The ARV report's nominal update period shall (3.xx) be 12 seconds for A3 equipment at ranges greater than 40 NM and less than or equal to 90 NM.

When the ARV report is required as defined in section §3.4.7.1, its acquisition range in the forward direction shall (R3.xx) be:

a. 20 NM for equipage class A1,

b. 40 NM for equipage class A2, and

c. 90 NM for equipage class A3.

The acquisition range requirements in directions other than forward shall (R3.xx) be consistent with those stated in Note 3 of Table 3-4(a).

3.3.3.1.4 Target State and Trajectory Change Report Acquisition, Update Interval, and Acquisition Range

The requirements for the minimum update periods for Target State (TS) and Trajectory Change (TC) reports - reports are functions of range. Tighter requirements (smaller required update periods) are placed on these reports for a time period equal to two update periods immediately following any change in the intent information previously broadcast. These requirements are specified in terms of acquisition range and required update interval to achieve a 95% confidence of receiving a TS or TC report within the specified acquisition range or time interval.

When there has been no change in intent information, the nominal update period for A2 equipage at ranges within 40 NM and for A3 equipage at ranges in the forward direction within 90 NM shall (R3.yy-A) be T_U, such that

$$T_U = \max\left(12\,s,\quad 0.45\frac{s}{NM}\cdot R\right)$$

where R is the range to the broadcasting aircraft and T_U is rounded to the nearest whole number of seconds. If implemented, these requirements are applicable to TS report update rates for A1 equipment for ranges of 20 NM or less.

When there is a change in the broadcast intent information as defined in §3.4.8.2 and §3.4.9.2, the update period for A2 equipage at ranges within 40 NM and for A3 equipage at ranges in the forward direction within 90 NM shall (R3.yy-B) be T_U, such that

$$T_U = \max\left(12\,s,\quad 0.22\frac{s}{NM}\cdot R\right)$$

where R is the range to the broadcasting aircraft and T_U is rounded to the nearest whole number of seconds. This higher update rate shall (R3.zz) be maintained for at least two update periods before returning to the nominal update rate. If implemented, these requirements are applicable to TS Report update rates for A1 equipment for ranges of 20 NM or less.

Note: It is desired that requirements R3.yy-A and R3.yy-B should be met by A2 equipment at ranges up to and including 50 NM and by A3 equipment up to and including 120 NM.

Table 3-4(c) shows the values for the required minimum update periods as calculated by the above formulae at the ranges indicated as required and desired for A2 and A3 aircraft.

If the TS report is implemented in ADS-B systems of equipage class A1, such systems shall (R3.xx) have a 20 NM acquisition range for TS Report. For equipage class A2, the acquisition range for TS reports and TC reports shall (R3.xx) be 40 NM, with 50 NM desired. For equipage class A3, the acquisition range for TC reports in the forward direction shall (R3.xx) be 90 NM, with 120 NM desired. The range requirements in all other directions for A3 equipment shall (R3.xx) be consistent with those stated in Note 3 of Table 3-4(a).

Table 3-4(c): Summary of TS and TC Report Acquisition Range and Update Interval Requirements

Operational Domain ®	**Terminal, En-route, and Oceanic / Remote Non-Radar –**				
Applicable Range ®	**R £ 20 NM**	**R = 40 NM**	**R = 50 NM**	**R = 90 NM**	**R = 120 NM**
Equipage Class ®	A1 optional A2 required	A2 required	A2 desired, A3 required	A3 required	A3 desired
TS Report Acquisition Range	20 NM (A1 optional)	40 NM (A2, A3 required)	50 NM (A2, A3 desired)	not required	not required
TC Report Acquisition Range	20 NM (A1 optional)	40 NM	50 NM (A2 desired)	90 NM	120 NM (A3 desired)
TS Report state change update period (note 3)	12 s	12 s	12 s (desired)	not required	not required
TC+0 state change update period (note 4)	12 s	12 s	12 s (desired)	20 s (desired)	26 s (desired)
TS Report nominal update period	12 s	18 s	23 s (desired)	not required	not required
TC+0 report nominal update period	12 s	18 s	23 s	41 s	54 s

Notes for Table 3-4(c):

1. *Table 3-4(c) is based on an air-air en-route scenario between two aircraft closing at 1200 knots, which is considered a worst-case scenario for deriving range requirements for ADS-B conflict alerting. See Appendix O for scenario details.*

2. *The ranges shown in Table 3-4(c) are meant to represent operational airspace with aircraft densities equivalent to those defined in Table 2-3.*

3. *The trigger conditions for broadcasting Target State reports at the "state change" update rate is specified in §3.4.8.2.*

4. *The trigger conditions for broadcasting Target Change reports at the "state change" update rate is specified in §3.4.9.2.*

3.3.3.2 State Vector Report Latency and Report Time Error Requirements

When ADS-B makes a SV report of aircraft/vehicle position and velocity to an application, this will occur at a time later than when the measurements were made. There are several sources of such delay or *latency* (defined below). Before the information reaches the ADS-B system, delays occur both in the navigation receiving system (a GNSS receiver for example) and in the data bus system that may be used to convey the information to ADS-B. Within the ADS-B system, delay can be caused by the computation time for preparing the transmission and for assembling the report. After the report leaves ADS-B, additional delays may occur.

Delays that occur prior to the information reaching ADS-B are not the subject of requirements in this MASPS. Delays occurring after the information is reported by ADS-B are likewise not considered in this MASPS.

Compensation may be applied to the reported information in order to adjust, at least approximately, for the changes in A/V state between the time of measurement and the time of the report. Compensation may be applied to position information while not being applied to velocity information. As a result, the position and velocity parts of a state vector report may apply to two different times. This produces a velocity lag error if the reporting aircraft is accelerating.

3.3.3.2.1 Latency Definitions

The following definitions are used in the requirements concerning latency.

- Latency: While the position and velocity of an A/V may be constantly changing, a particular measurement applies to the true state at a certain time, called the "time of measurement." Latency, for cases in which compensation is not used, is the time difference between the time of measurement and the time it is reported at the ADS-B output (the latter minus the former). For cases in which compensation is used, the time of applicability of position and velocity will differ in general, and the report contains the time of applicability of position. Position latency is the difference, if any, between the time of applicability and the time the information is reported at the ADS-B output (the latter minus the former). Velocity latency is defined in the same way, but will in general, have a different value. Latency includes the total time differences, whether it is constant with time or variable, and whether it is known by the application or uncertain.

- ADS-B Latency: This is the component of latency attributable to the ADS-B system. Typically the source will make measurements periodically, and will provide the information to ADS-B once per period. If the ADS-B timing structure is independent of the source timing, as is typical, there will be a waiting time (a contribution to latency) between when the information is provided by the source and when it is transmitted. The average value of this asynchronization wait is one half the source period. This contribution to latency is attributed to ADS-B. If a data bus is used to convey information from the source to ADS-B, it may contribute latency, but that contribution is not attributed to ADS-B latency. Similarly, a data bus may be used to convey information from ADS-B to an application, and any resulting latency is not attributed to ADS-B.

- Report time error: Each ADS-B report includes timing information. Report time error is defined as the reported time minus the true time of the measurement. The time in the report is taken to be the time of the position measurement. If the times of applicability of the position and velocity are different and are not reported separately, then the application can use the single reported time for both, with a resulting report time error.

- Differential Delay: The difference in adjacent aircraft report times used by a third party surveillance application. Differential delay, relative to the output of a separate surveillance system e.g., radar, will also influence position registration error when the two outputs are combined.

3.3.3.2.2 State Vector Latency Requirements

For NAC_P less than 9, ADS-B latency of the reported information shall (R3.16) be less than 1.2 s with 95 percent confidence. For $NAC_P \geq 9$, ADS-B latency shall (R3.17) be less than 0.4 s with 95% confidence. The standard deviation of the report time error shall (R3.18) be less than 0.5 s (1 sigma). The mean report time error for position shall (R3.19) not exceed 0.5 s. The mean report time error for velocity shall (R3.20) not exceed 1.5 s. Differential delay errors should be considered and, if necessary, compensated for by the using application. ADS-B is not required to compensate for differential delays; however, all necessary information to perform such compensation is included in the ADS-B state vector report. Appendices G, J, and K provide a more detailed discussion of the different sources of latency, and provide the rationale for these numerical requirements.

3.4 ADS-B Messages And Reports

This section provides requirements and definition of ADS-B reports and the relationship between these reports and the received messages. The ADS-B output report definitions establish the standard contents and conditions for outputting data qualified for user applications. Exchange of broadcast messages and report assembly considerations are discussed in §3.4.2. Report data elements are specified in §3.4.3 to §3.4.9 and standardized according to content, nomenclature, parameter type, applicable coordinate system, logical content, and operational conditions. Reports required for each Equipment Class and supporting message contents are defined in §3.3.2. Report contents and message requirements are based on the information requirements summarized in Table 2-2. These definitions provide the basis for:

- Independence between applications and broadcast link technologies

- Interoperability of applications utilizing different ADS-B technologies.

Specific digital formats are not defined since interface requirements will determine those details. Such interfaces may be internal processor buses or inter-system buses such as those described in ARINC, IEEE, and military standards. Additional information requirements may develop in the future and result in expansion to the report definitions specified in this document. ADS-B system designs should be sufficiently flexible to accommodate such future expansion.

3.4.1 Report Assembly Design Considerations

Three report types are defined as ADS-B outputs to applications. They provide flexibility in meeting delivery and performance requirements for the information needed to support the operations identified in Section 2. Report types, also shown in Figure 3-8, are:

- Surveillance State Vector Report (SV, §3.4.3);
- Mode-Status Report (MS, §3.4.4);
- Various On-Condition Reports (OC, §3.4.5) – a category that includes the following report types:
  - Air Referenced Velocity Report (ARV, §3.4.7),
  - Target State Report (TSR, §3.4.8),
  - Trajectory Change Report (TC+0 or TC+n report§3.4.9), and
  - Other On-Condition Reports, which may possibly be defined in future versions of this MASPS.

All interactive participants must receive messages and assemble reports specified for the respective equipage class (Table 3-3(a)). All transmitting participants must output at least the minimum data for the SV and MS reports. The minimum requirements for exchanged information and report contents applicable for equipage classes are provided in §3.3.2.

3.4.2 ADS-B Message Exchange Technology Considerations in Report Assembly

ADS-B participants can vary both in the information exchanged and in the applications supported. ADS-B reports are assembled from received ADS-B messages. Message formats are defined in MOPS or equivalent specifications for each link technology chosen for ADS-B implementation. Reports are independent of the particular message format and network protocol. In some ADS-B broadcast exchange technologies the information may be conveyed as a single message, while others may utilize multiple messages which require assembly in the receiving subsystem to generate the ADS-B report. The report assembly function must be performed by the ADS-B subsystem prior to disseminating the report to the application.

Broadcast technologies vary in broadcast rate and probability of message reception. The receiving subsystem, therefore, must process messages compatibly with the message delivery performance to satisfy required performance as observed in the ADS-B report outputs. Also, data compression techniques may be used to reduce the number of transmitted bits in message exchange designs.

The messages shall (R3.29) be correlated, collated, uncompressed, re-partitioned, or otherwise manipulated as necessary to form the output reports specifically defined in §3.4.3 to §3.4.9 below. The message and report assembly processing capability of the receiving subsystem shall (R3.30) support the total population of the participants within detection range provided by the specific data link technology.

Receiving subsystem designs must provide reports based on all decodable messages received, i.e., for each participant the report shall (R3.31) be updated and made available to ADS-B applications any time a new message containing all, or a portion of, its component information is received from that participant. The Report Assembler function converts the received messages into the reports appropriate to the information conveyed from the transmitting participant. The applicable reports shall (R3.32) be made available to the applications on a continual basis in accordance with the local system interface requirements.

Each ADS-B report contains an address, for the purpose of enabling the receiver to associate the receptions into a single track. If the ADS-B design uses the ICAO 24-bit address, then there shall (R3.33) be agreement between the address currently being used by the Mode S transponder and the reported ADS-B address, for aircraft with both transponder and ADS-B.

3.4.3 State Vector Report

Table 3.4.3 lists the report elements that comprise the state vector (SV) report. The SV report contains information about an aircraft or vehicle's current kinematic state. Measures of the state vector quality are contained in the NIC element of the SV report and in the NAC_P, NAC_V, NIC_{baro} and SIL elements of the Mode Status Report (paragraph 3.4.4 below).

Table 3.4.3: State Vector Report Definition.

	SV Elem. #	Contents	[Resolution or # of bits]	Required from surface participants	Required from airborne participants	Reference Section	Notes
ID	1	Participant Address	[24 bits]	•	•	2.1.2.2.2.1	
	2	Address Qualifier	[4 bits]	•	•	2.1.2.2.2.2	1
TOA	3	Time Of Applicability	[0.2 s]	•	•	3.4.3.3	
Geometric Position	4a	Latitude (WGS-84)		•	•	3.4.3.4	2, 3
	4b	Longitude (WGS-84)		•	•		
	4c	Horizontal Position Valid	[1 bit]	•	•	3.4.3.5	
	5a	Geometric Altitude		•		3.4.3.6	3, 4
	5b	Geometric Altitude Valid	[1 bit]	•		3.4.3.7	
Horizontal Velocity	6a	North Velocity while airborne		•		3.4.3.8	3
	6b	East Velocity while airborne		•			3
	6c	Airborne Horizontal Velocity Valid	[1 bit]	•		3.4.3.9	
	7a	Ground Speed while on the surface	[1 knot]		•	3.4.3.10	
	7b	Surface Ground Speed Valid	[1 bit]		•	3.4.3.11	
Heading	8a	Heading while on the Surface	[6° or better (6 bits)]		•	3.4.3.12	
	8b	Heading Valid	[1 bit]		•	3.4.3.13	
Baro Altitude	9a	Pressure Altitude		•		3.4.3.14	3, 4
	9b	Pressure Altitude Valid	[1 bit]	•		3.4.3.15	
Vertical Rate	10a	Vertical Rate (Baro/Geo)		•		3.4.3.16	3
	10b	Vertical Rate Valid	[1 bit]	•		3.4.3.17	
NIC	11	Navigation Integrity Category	[4 bits]	•	•	3.4.3.18	
Report Mode	12	SV Report Mode	[2 bits]			3.4.3.19	

Notes for Table 3.4.3:

1. *The minimum number of bits required by this MASPS for the Address Qualifier field is just one bit. However, when ADS-B is implemented on a particular data link, more than one bit may be required for the address qualifier if that data link supports other services in addition to the ADS-B service. The number of bits shown in the table for the Address Qualifier field is 4 only because experience in encoding that field the MOPS for particular ADS-B data links seems to indicate that 4 bits is sufficient for encoding this field.*

2. *A horizontal position resolution finer than 20 m will be required if NAC_P element of the MS report (§3.4.4.11) is 9 or greater (§2.1.2.13).*

3. *Resolution requirements of these elements must be sufficient to meet the error requirements specified in Table 3-4(a).*

4. *Future revisions of this MASPS may not require that both geometric and pressure altitudes – if available - be broadcast at the SV rate. Conditions will need to be specified as to when each altitude must be the "primary" altitude being sent at the SV rate.*

3.4.3.1 Air/Ground State

A transmitting ADS-B participant's *air/ground state* is an internal state in the transmitting ADS-B subsystem that affects which SV report elements are to be broadcast, but which is not required to be broadcast in ADS-B messages from that participant.

Notes:

1. *It is possible that a future edition of this MASPS would require a participant's air/ground state to be broadcast. This would occur if an operational concept for a user application that needs air/ground state were to be included in the ASA MASPS currently being developed.*

2. *A transmitting ADS-B participant's air/ground state also affects whether the aircraft size (length and width) codes in the MS report are to be broadcast. (See §3.4.4.6 below.)*

A transmitting participant's air/ground state has the following possible values:

- "Known to be airborne,"
- "Known to be on the surface," and
- "Uncertain whether airborne or on the surface."

3.4.3.1.1 Determination of Air/Ground State

A transmitting ADS-B participant applies the following tests to determine its air/ground state:

1. If a transmitting ADS-B participant is *not* equipped with a means, such as a weight-on-wheels switch, to determine whether it is airborne or on the surface, and that participant's emitter category is one of the following, then it shall (R3.xx) set its air/ground state to "known to be airborne" :

   a. Light Aircraft
   b. Glider or Sailplane
   c. Lighter Than Air
   d. Unmanned Aerial Vehicle
   e. Ultralight, Hang Glider, or Paraglider
   f. Parachutist or Skydiver
   g. Point Obstacle
   h. Cluster Obstacle
   i. Line Obstacle

   Note 1: Because it is important for fixed ground or tethered obstacles to report altitude, Point Obstacles, Cluster Obstacles, and Line obstacles always report the "Airborne" state.

2. If a transmitting ADS-B participant is *not* equipped with a means, such as a weight-on-wheels switch, to determine whether it is airborne or on the surface, and that participant's emitter category is one of the following, then that participant shall (R3.xx) set its air/ground state to "known to be on the surface" :

   a. Surface Vehicle – Emergency
   b. Surface Vehicle – Service

3. If a transmitting ADS-B participant is *not* equipped with a means, such as a weight-on-wheels switch, to determine whether it is airborne or on the surface, and that participant's emitter category is "rotorcraft," then that participant shall (R3.xx) set its air/ground state to "uncertain whether airborne or on the surface."

Note 2: Because of the unique operating capability of rotorcraft (i.e., hover, etc.) an operational rotorcraft always reports the "uncertain" air/ground state, unless the "surface" state is specifically declared. This causes the rotorcraft to transmit those SV elements that are required from airborne ADS-B participants.

4. If a transmitting ADS-B participant is *not* equipped with a means, such as a weight-on-wheels switch, to determine whether it is airborne or on the surface, and its ADS-B emitter category is not one of those listed under tests 1, 2, and 3 above, then that participant's ground speed (GS), airspeed (AS) and radio height (RH) shall (R3.xx-A) be examined, provided that some or all of those three parameters are available to the transmitting ADS-B subsystem. If GS < 100 knots, or AS < 100 knots, or RH < 100 feet, then the transmitting ADS-B participant shall (R3.xx-B) set its Air/Ground state to "known to be on the surface."

5. If a transmitting ADS-B participant *is* equipped with a means, such as a weight-on-wheels switch, to determine automatically whether it is airborne or on the surface, and that automatic means indicates that the participant is airborne, then that participant shall (R3.xx-A) set its air/ground state to "known to be airborne."

6. If a transmitting ADS-B participant *is* equipped with a means, such as a weight-on-wheels switch, to determine automatically whether it is airborne or on the surface, and that automatic means indicates that the participant is on the surface, then the following additional tests shall (R3.xx) be performed to validate the "on-the-surface" condition:

   a. If the participant's ADS-B emitter category is any of the following:
      "Small Aircraft" or
      "Medium Aircraft" or
      "High-Wake-Vortex Large Aircraft" or
      "Heavy Aircraft" or
      "Highly Maneuverable Aircraft" or
      "Space or Trans-atmospheric Vehicle"

      and one or more of the following parameters is available to the transmitting ADS-B system:
      Ground Speed (GS) or
      Airspeed (AS) or
      Radio height from radio altimeter (RH)

      and any of the following conditions is true:
      GS > 100 knots or
      AS > 100 knots or
      RH > 100 ft,

      then the participant shall (R3.xx-A) set its Air/Ground state to "known to be airborne."

   b. Otherwise, the participant shall (R3.xx-B) set its Air/Ground state to "known to be on the surface."

3.4.3.1.2 Effect of Air/Ground State

The set of SV elements to be broadcast by ADS-B participants is determined by those participants' air/ground state as follows:

a. ADS-B participants that are known to be on the surface shall (R3.xxx) transmit those State Vector report elements that are indicated with bullets ("•") in the "required from surface participants" column of Table 3.4.3.

b. ADS-B participants that are known to be airborne shall (R3.xxx) transmit those SV report elements that are indicated by bullets ("•") in the "required from airborne participants" column of Table 3.4.3.

c. ADS-B participants for which the air/ground state is uncertain shall (R3.xx) transmit those SV report elements that are indicated by bullets in the "required from airborne participants" column. It is recommended that such participants should also transmit those SV elements that are indicated with bullets in the "required from surface participants" column.

3.4.3.2 SV Report Update Requirements

Required SV report update rates, described by operating range, are given in Table 3-4(a) in §3.3.3.1 above.

a. A receiving ADS-B subsystem shall (R3.36) update the SV report that it provides to user applications about a transmitting ADS-B participant whenever it receives messages from that participant providing updated information about any of the SV report elements.

b. For ADS-B systems that use segmented messages for SV data, *time-critical SV report elements* that are not updated in the current received message shall (R3.35) be estimated whenever the SV report is updated. The *time-critical SV elements* are defined as the following:

   i. Geometric position (latitude, longitude, geometric height, and their validity flags – elements 4a, 4b, 4c, 5a, 5b);

   ii. Horizontal velocity and horizontal velocity validity (elements 6a, 6b, 6c, 7a, 7b);

   iii. Heading while on the surface (elements 8a, 8b);

   iv. Pressure altitude (elements 9a, 9b);

   v. Vertical rate (elements 10a, 10b); and

   vi. NIC (element 11).

c. For time-critical elements of the SV report, a receiving ADS-B subsystem's report assembly function shall (R3.38) indicate "no data available" if no data are received in the preceding coast interval specified in Table 3-4(a) (§3.3.3.1.1 above).

d. For non-time-critical elements of the SV report, the report assembly function shall (R3.xx) indicate "no data available" if no data are received in the preceding 24 seconds.

3.4.3.3 Time of Applicability (TOA) Field for SV Report

The Time of Applicability (TOA) field in the SV report describes the time at which the elements of that report are valid.

Note: As mentioned in the definition of latency in §3.3.3.2.1 above, the times of applicability of position and velocity may differ. The TOA field in the SV report contains the time of applicability of position.

The time of applicability (TOA) relative to local system time shall (R3.37) be updated with each State Vector report update.

Requirements on the accuracy of the TOA field in the SV report are given in §3.3.3.2.2 above, and may be paraphrased as follows:

a. The standard deviation of the SV report time error is to be less than 0.5 s.

b. The mean report time error for the position elements of the SV report is not to exceed 0.5 s.

c. The mean report time error for the velocity elements of the SV report is not to exceed 1.5 s.

3.4.3.4 Horizontal Position

Horizontal position (§2.1.2.4) shall (R3.xx) be reported as WGS-84 latitude and longitude. Horizontal position shall (R3.xx) be reported with the full range of possible latitudes (-90° to +90°) and longitudes (-180° to +180°).

Horizontal position shall (R3.xx) be communicated and reported with a resolution sufficiently fine that it does not compromise the accuracy reported in the NAC_P field of the Mode-Status report (§2.1.2.13 and §3.4.4). Moreover, horizontal position shall (R3.xx) be communicated and reported with a resolution sufficiently fine that it does not compromise the one-sigma maximum ADS-B contribution to horizontal position error, σ_{hp}, listed in Table 3-4(a): 20 m for airborne participants, or σ_{hp} = 2.5 m for surface participants.

3.4.3.5 Horizontal Position Valid Field

The Horizontal Position Valid field in the SV report shall (R3.xx-A) be set to ONE if a valid horizontal position is being provided in geometric position (latitude and longitude) fields of that report; otherwise, the Horizontal Position Valid field shall (R3.xx-B) be ZERO.

3.4.3.6 Geometric Altitude Field

Geometric altitude shall (R3.xx) be reported with a range from -1,000 feet up to +100,000 feet. If the NAC_P code reported in the MS report (§2.1.2.13) is 9 or greater, geometric altitude shall (R3.xx) be communicated and reported with a resolution sufficiently fine that it does not compromise the vertical accuracy reported in the NAC_P field. Moreover, geometric altitude shall (R3.xx) be communicated and reported with a resolution sufficiently fine that it does not compromise the one-sigma maximum ADS-B contribution to vertical position error, σ_{vp}, listed in Table 3-4(a): σ_{vp} = 30 feet for airborne participants.

Note: A resolution of 100 feet or finer is sufficient not to compromise the one-sigma (one standard deviation) ADS-B contribution to vertical position error listed in Table 3-4(a). This is because the error introduced by rounding altitude to the nearest multiple of 100 feet has a uniform probability distribution, for which the standard deviation is 100 feet divided by the square root of 12, that is, about 28.9 feet.

3.4.3.7 Geometric Altitude Valid Field

The Geometric Altitude Valid field in the SV report is a one-bit field which shall (R2.xx) be ONE if valid data is being provided in the Geometric Altitude field (§3.4.3.6), or ZERO otherwise.

3.4.3.8 Geometric Horizontal Velocity

Geometric horizontal velocity is the horizontal component of the velocity of an A/V with respect to the earth (or with respect to an earth-fixed referenced system, such as the WGS-84 ellipsoid). The range of reported horizontal velocity shall (R2.22) accommodate speeds of up to 250 knots for surface participants and up to 4000 knots for airborne participants. Horizontal velocity shall (R3.xx) be communicated and reported with a resolution sufficiently fine that it does not compromise the accuracy reported in the NAC_V field of the Mode-Status report. Moreover, horizontal velocity shall (R3.xx) be communicated and reported with a resolution sufficiently fine that it does not compromise the one-sigma maximum ADS-B contribution to horizontal velocity error, σ_{hv}, listed in Table 3-4(a): that is, 0.5 m/s (about 1 knot) for airborne participants with speeds of 600 knots or less, or 0.25 m/s (about 0.5 knot) for surface participants.

Note: The rounding of velocity to the nearest encoded representation may be modeled with a uniform probability distribution. As such, the standard deviation (one-sigma velocity error, s_{hv}) due to rounding to the nearest possible encoded representation is the weight of the LSB divided by the square root of 12. Thus, s_{hv} = 0.5 m/s (about 1 knot) for airborne participants implies a resolution of $res_{hv} = s_{hv} \cdot \sqrt{12}$ = 1.73 m/s (about 3.4 knots), so even a horizontal velocity resolution of 2 knots is sufficiently fine to meet the constraint imposed by Table 3-4(a) on airborne participants with speeds up to 600 knots. Likewise, a horizontal velocity resolution of 1 knot is sufficiently fine to satisfy the constraint imposed by Table 3-4(a) for surface participants.

3.4.3.9 Airborne Horizontal Velocity Valid Field

The Airborne Horizontal Velocity Valid field in the SV report is a one-bit field which shall (R3.xx-A) be set to ONE if a valid horizontal geometric velocity is being provided in the "North Velocity while airborne" and "East velocity while airborne" fields of the SV report; otherwise, the "Airborne Horizontal Velocity Valid" field shall (R3.xx-B) be ZERO.

3.4.3.10 Ground Speed While On the Surface Field

The ground speed (the magnitude of the geometric horizontal velocity) of an A/V that is known to be on the surface shall (R3.xx) be reported in the "ground speed while on the surface" field of the SV report. For A/Vs moving at ground speeds less than 70 knots, the ground speed shall (R3.xx) be communicated and reported with a resolution of 1 knot or finer. Moreover, the resolution with which the :ground speed while on the surface" field is communicated and reported shall be sufficiently fine so as not to compromise the accuracy of that speed as communicated in the NAC_V field of the MS report (§2.1.2.14 below).

3.4.3.11 Surface Ground Speed Valid Field

The Surface Ground Speed Valid field in the SV report is a one-bit field which shall (R3.xx) be ONE if valid data is available in the Ground Speed While on the Surface field (§3.4.3.10), or ZERO otherwise.

3.4.3.12 Heading While On the Surface Field

Heading (§2.1.2.9) indicates the orientation of an A/V, that is, the direction in which the nose of an aircraft is pointing. ADS-B Participants are not required to broadcast heading if their length code (part of the aircraft size code, §2.1.2.3 above) is 0. However, each ADS-B participant that reports a length code of 1 or greater shall (R2.xx) transmit messages to support the heading element of the SV report when that participant is on the surface and has a source of heading available to its ADS-B transmitting subsystem.

Heading shall (R3.xx-A) be reported for the full range of possible headings (the full circle, from 0° to nearly 360°). The heading of surface participants shall (R3.xx-B) be communicated and reported with a resolution of 6 degrees of arc or finer.

Notes:

1. *If heading is encoded as a binary fraction of a circle, a resolution of 6° of arc or finer would require at least 6 binary bits.*

2. *The reference direction for heading (true north or magnetic north) is communicated in the Mode-Status report (paragraph 3.4.4).*

3. *For operations at some airports, heading may be required to enable proper orientation and depiction of an A/V by applications supporting those surface operations.*

3.4.3.13 Heading Valid Field

The "heading valid" field in the SV report shall (R3.xx-A) be ONE if a valid heading is provided in the "heading while on the surface" field of the SV report; otherwise, it shall (R3.xx-B) be ZERO.

3.4.3.14 Pressure Altitude Field

Barometric pressure altitude shall (R2.18) be reported referenced to standard temperature and pressure (1013.25 hPa or mB, or 29.92 in Hg). Barometric pressure altitude shall (R3.xx) be reported over the range of -1,000 feet to +100,000 feet.

If a pressure altitude source with 25-foot or better resolution is available to the ADS-B transmitting subsystem, then pressure altitude from that source shall (R3.xx-A) be communicated and reported with 25-foot or finer resolution. Otherwise, if a pressure altitude source with 100-foot or better resolution is available, pressure altitude from that source shall (R3.xx-B) be communicated and reported with 100-foot or finer resolution.

Note: A field is reserved in the MS report ("BAQ" field, §3.4.4.14) for future use in reporting the accuracy and resolution of the pressure altitude provided in the SV report.

3.4.3.15 Pressure Altitude Valid Field

The "pressure altitude valid" field in the SV report is a one-bit field which shall (R3.xx-A) be ONE if valid information is provided in the "pressure altitude" field; otherwise, the "pressure altitude valid" field shall be ZERO.

3.4.3.16 Vertical Rate Field

The "vertical rate" field in the SV report contains the altitude rate (§2.1.2.8) of an airborne ADS-B participant. This shall (R3.xx) be either the rate of change of pressure altitude or of geometric altitude, as specified by the "vertical rate type" element in the MS report. The range of reported vertical rate shall (R3.xx) accommodate up to ±32000 ft/min for airborne participants. Geometric vertical rate shall (R3.xx) be communicated and reported with a resolution sufficiently fine that it does not compromise the accuracy reported in the NAC_V field of the Mode-Status report. Moreover, vertical rate shall (R3.xx) be communicated and reported with a resolution sufficiently fine that it does not compromise the one-sigma maximum ADS-B contribution to vertical rate error, σ_{vv}, listed in Table 3-4(a): that is, 1.0 ft/s for airborne participants.

Note: Future versions of this MASPS will require that the resolution of barometric altitude rate be sufficiently fine that it does not compromise the Barometric Altitude Quality (BAQ) field (§3.4.4.14) reported in the MS report, which is not defined in this version of the MASPS.

3.4.3.17 Vertical Rate Valid Field

The "vertical rate valid" field in the SV report is a one-bit field which shall (R3.xx-A) be ONE if valid information is provided in the "vertical rate" field; otherwise, the "vertical rate valid" field shall be ZERO.

3.4.3.18 Navigation Integrity Category (NIC) Field

The NIC field in the SV report is a 4-bit field that shall (R3.xx) report the Navigation Integrity Category described in §2.1.2.12 above.

3.4.3.19 Report Mode Field

The "Report Mode" provides a positive indication when SV acquisition is complete and all applicable data sets and modal capabilities have been determined for the participant or that a default condition is determined by the Report Assembly function. The information for this SV element is not transmitted over the ADS-B data link, but is provided by the report assembly function at the receiving ADS-B participant. Table 3.4.3.18 lists the possible values for the SV Report Mode.

Table 3.4.3.19 : SV Report Mode Values.

Value	Meaning
0	Acquisition
1	Track
2	Default

3.4.4 Mode Status Report

The mode-status (MS) report contains current operational information about the transmitting participant. This information includes participant type, mode specific parameters, status data needed for certain pair-wise operations, and assessments of the integrity and accuracy of position and velocity elements of the SV report. These elements require lower update rates than the SV report. Specific requirements for a participant to supply data for and/or generate this report subgroup will vary according to the equipage class of each participant. Subsection 3.3.2 defines the required capabilities for each Equipage Class defined in Section 3.2.3. Equipage classes define the level of MS information to be exchanged from the source participant to support correct classification onboard the user system.

The Mode-Status report for each acquired participant contains the unique participant address for correlation purposes, static and operational mode information and Time of Applicability. Contents of the Mode-Status report are summarized in Table 3.4.4.

The static and operational mode data includes the following information:

- Capability Class (CC) Codes – used to indicate the capabilities of a transmitting ADS-B participant.
- Operational Mode (OM) Codes – used to indicate the current operating mode of a transmitting ADS-B participant.

For each participant the Mode-status report shall (R3.41) be updated and made available to ADS-B applications any time a new message containing all, or a portion of, its component information is accepted from that participant.

Table 3.4.4: Mode-Status (MS) Report Definition.

	MS Elem. #	Contents [Resolution or # of bits]	Elements That Trigger Status Change Report	Reference Section	Notes
ID	1	Participant Address [24 bits]		2.1.2.2.2.1	
	2	Address Qualifier [4 bits]		2.1.2.2.2.2	1
TOA	3	Time of Applicability [1 s resolution]		3.4.4.2	
Version	4	ADS-B Version Number [3 bits]		3.4.4.3	
ID, Continued	5a	Call sign [up to 8 alpha-numeric characters]		3.4.4.4	
	5b	Emitter Category [5 bits]		3.4.4.5	
	5c	A/V Length and Width Codes [4 bits]		3.4.4.6	2
Status	6a	Mode-Status Data Available [1 bit]		3.4.4.7	
	6b	Emergency/Priority Status [3 bits]		3.4.4.8	3
CC, Capability Codes	7	Capability Class Codes [16 bits]		3.4.4.9	
		7a: CDTI display capability [1 bit]		3.4.4.9.1	
		7b: TCAS/ACAS installed and operational [1 bit]	•	3.4.4.9.2	
		7c: (Reserved for Service Level) [4 bits]		3.4.4.9.3	
		7d: TS report Capability Flag [1 bits]		3.4.4.9.5	
		7e: TC report Capability Level [2 bits]		3.4.4.9.6	
		(CC Codes reserved for future growth) [7 bits]		3.4.4.9.7	
OM, Operational Mode	8	Operational Mode Parameters [16 bits]		3.4.4.10	
		8a: TCAS/ACAS resolution advisory active [1 bit]	•	3.4.4.10.1	4
		8b: IDENT Switch Active [1 bit]		3.4.4.10.2	3
		8c: Requesting ATC services [1 bit]		3.4.4.10.3	
		(Reserved for future growth) [13 bits]		3.4.4.10.4	
SV Quality	9a	Nav. Acc. Category for Position (NAC_P) [4 bits]	•	3.4.4.11	4
	9b	Nav Acc. Category for Velocity (NAC_V) [3 bits]	•	3.4.4.12	4
	9c	Surveillance Integrity Level (SIL) [2 bits]	•	3.4.4.13	4
	9d	(Res. For BAQ, Barometric Altitude Quality) [2 bits]		3.4.4.14	
	9e	NIC_{baro} - Altitude Cross Checking Flag [1 bit]		3.4.4.15	
Data Reference	10a	True/Magnetic Heading [1 bit]		3.4.4.16	
	10b	Vertical Rate Type (Baro./Geo.) [1 bit]		3.4.4.17	
Other	11	Reserved for Flight Mode Specific Data [3 bits]		3.4.4.18	

Notes for Table 3.4.4:

1. *The minimum number of bits required by this MASPS for the Address Qualifier field is just one bit. However, when ADS-B is implemented on a particular data link, more than one bit may be required for the address qualifier if that data link supports other services in addition to the ADS-B service. For example, address qualifier bits might be needed to distinguish reports about TIS-B targets from reports about ADS-B targets. The number of bits shown in the table for the Address Qualifier field is 4 only because experience in encoding that field the MOPS for particular ADS-B data links seems to indicate that 4 bits is sufficient for encoding this field.*

2. *The aircraft size code only has to be transmitted by aircraft above a certain size, and only while those aircraft are on the ground. (See section 2.1.2.3 for details.)*

3. *These elements are primarily for air-to-ground use. Update rate requirements for ground applications are not defined in this MASPS. If higher rates are later deemed to be required, they will be addressed in a future revision of this MASPS.*

4. *Changes to these elements will be communicated in a new Status Change (SC) on-condition report. Update rates for this report and operational scenario to be used to evaluate requirements of that report are to be defined in a future revision of this MASPS (§3.4.6).*

3.4.4.1 MS Report Update Requirements

The report assembly function shall (R3.43-A) provide update when received. For those elements indicated in Table 3.4.4 as "elements that trigger status change report", the report assembly function shall (R3.43-B) indicate the data has not been refreshed with the "Mode Status Data Available" bit (§3.4.4.7) if no update is received in the preceding 24 second period.

Note: The 24-second period before which the "Mode-Status Data Available" bit is cleared was chosen as being the longest coast interval for SV reports, as indicated in Table 3-4(a) above.

3.4.4.2 Time of Applicability (TOA) Field for MS Report

The time of applicability relative to local system time shall (R3.42) be updated with every Mode-Status report update.

3.4.4.3 ADS-B Version Number

The ADS-B Version Number is a 3-bit field which that specifies the ADS-B version of the transmitting ADS-B system. The ADS-B Version Number shall (R3.xx) be defined in the ADS-B link MOPS and conveyed through MS reports.

Notes:

Coding of this field is not specified in this MASPS, but is left to lower level documents.

It is recommended that provisions be made within the receiving subsystem to map the version number to version of the MASPS so that reports can be shared among ownship ADS-B subsystems from different data links.

3.4.4.4 Call Sign Field

An ADS-B participant's call sign (§2.1.2.2.1) is conveyed in the Call Sign field of the MS report. The call sign shall (R3.xx) consist of up to 8 alphanumeric characters. The characters of the call sign shall (R3.xx) consist only of the capital letters A-Z, the decimal digits 0-9, and – as trailing pad characters only – the "space" character.

3.4.4.5 Emitter Category Field

An ADS-B participant's category code (§2.1.2.2.3) is conveyed in the Emitter Category field of the MS report. The particular encoding of the emitter category is not specified in this MASPS, being left for lower level specification documents, such as the MOPS for a particular ADS-B data link. Provision in the encoding shall (R3.xx) be made for at least 24 distinct emitter categories, including the particular categories listed in §2.1.2.2.3 above.

3.4.4.6 A/V Length and Width Codes

The "A/V Length and Width Codes" field in the MS field is a 4-bit field that describes the amount of space that an aircraft or ground vehicle occupies. The aircraft length and width codes shall (R3.xx) be as described in Table 3.4.4.6 below. The aircraft size code is a four-bit code, in which the 3 most significant bits (the length code) classify the aircraft into one of eight length categories, and the least significant bit (the width code) classifies the aircraft into a "narrow" or "wide" subcategory.

Each aircraft shall (R3.xx) be assigned the smallest length and width codes for which its overall length and wingspan qualify it.

Note: For example, consider a powered glider with overall length of 25 m and wingspan of 50 m. Normally, an aircraft of that length would be in length category 0. But since the wingspan exceeds 33 m, it will not fit within even the "wide" subcategory of length category 0. Such an aircraft would be assigned length category 3 and width category 1, meaning "length less than 54 m and wingspan less than 52 m."

Each aircraft ADS-B participant for which the length code is 1 or more (length greater than or equal to 30 m or wingspan greater than 33 m) shall (R3.xx) transmit its aircraft size code while it is known to be on the surface. For this purpose, the determination of when an aircraft is on the surface shall (R3.xx) be as described in §3.4.3.1.1 above.

Table 3.4.4.6: Aircraft Size (Length and Width) Codes.

Length Code (3 MSBs)			Width (Wingspan) Code (LSB)	
dec.	binary	Length Category	Narrow (LSB = 0)	Wide (LSB = 1)
0	0 0 0	L < 30 m	W < 16.5 m	16.5 m ≤ W < 33 m
1	0 0 1	L < 38 m	W < 30.5 m	30.5 m ≤ W < 38 m
2	0 1 0	L < 46 m	W < 38 m	38 m ≤ W < 48 m
3	0 1 1	L < 54 m	W < 42 m	42 m ≤ W < 52 m
4	1 0 0	L < 62 m	W < 51.5 m	51.5 m ≤ W < 65 m
5	1 0 1	L < 70 m	W < 66.5 m	66.5 m ≤ W < 74 m
6	1 1 0	L < 78 m	W < 69.5 m	69.5 m ≤ W < 80 m
7	1 1 1	L ≥ 78 m	W < 84 m	W ≥ 84 m

3.4.4.7 Mode-Status Data Available Field

The Mode-Status Data Available field is a one-bit field in the MS report. The report assembly function shall (R3.xx-A) set this field to ZERO if no data has be received within 24 seconds under the conditions specified in 3.4.4.1; otherwise the report assembly function shall (R3.xx-B) set this bit to ONE.

3.4.4.8 Emergency/Priority Status Field

The emergency/priority status field in the MS report is a 3-bit field which shall (R3.xx) be encoded as indicated in Table 3.4.4.8.

Table 3.4.4.8: Emergency/Priority Status Encoding.

Value	Meaning
0	No emergency / not reported
1	General emergency
2	Lifeguard / medical emergency
3	Minimum fuel emergency
4	No communications
5	Unlawful interference
6	Downed Aircraft
7	(Reserved for future definition)

3.4.4.9 Capability Class (CC) Codes Field

A transmitting ADS-B participant broadcasts Capability Class (CC) codes (§2.1.2.10) so as to indicate capabilities that may be of interest to other ADS-B participants. The subfields of the CC codes field are described in the following subparagraphs.

3.4.4.9.1 CDTI Traffic Display Capability

The CC code for "CDTI based traffic display capability" shall be set to ONE if the transmitting aircraft has the capability of displaying nearby traffic on a Cockpit Display of Traffic Information (CDTI). Otherwise, this CC code shall be ZERO.

3.4.4.9.2 TCAS/ACAS Installed and Operational

The CC code for "TCAS/ACAS installed and operational" shall be set to ONE if the transmitting aircraft is fitted with a TCAS II or ACAS computer and that computer is turned on and operating in a mode that can generate Resolution Advisory (RA) alerts. Otherwise, this CC code shall be ZERO.

Note: This field is also contained in the Status Change (SC) Report (§3.4.6). A change in the value of this field will trigger the transmission of messages supporting the SC report (§3.4.6.1).

3.4.4.9.3 Service Level of Transmitting A/V

At least four bits (sixteen possible encodings) shall (R3.xx) be reserved in the capability class codes for the "service level" of the transmitting ADS-B participant. ADS-B equipment conforming to the current version of this MASPS (DO-242A) shall (R2.xx) set the Service Level code to ZERO.

Note: When Service Levels are defined in the ASA MASPS, future versions of this MASPS will define Service Levels other than ZERO.

3.4.4.9.4 ARV Capability Flag

The ARV Capability Flag is a one-bit field that shall be encoded as in Table 3.4.4.8.4.

Table 3.4.4.8.4: ARV Capability Flag.

ARV Capability Flag	Meaning
0	No capability for Air Reference Velocity Reports.
1	Capability of sending Air Reference Velocity Reports.

3.4.4.9.5 TS Report Capability Flag

The TS Report Capability Flag is a one-bit field that shall (R3.xx) be encoded as in Table 3.4.4.8.5.

Table 3.4.4.8.5: TS Report Capability Flag.

TS Report Capability Flag	Meaning
0	No capability for Target State Reports.
1	Capability of sending Target State Reports.

3.4.4.9.6 TC Report Capability Level

The TC Report Capability Level is a two-bit field that shall (R3.xx) be encoded as in Table 3.4.4.9.6.

Table 3.4.4.9.6: TC Report Capability Levels.

TC Report Capability Level	Meaning
0	No capability for Trajectory Change Reports
1	Capability of sending information for TC+0 report only.
2	Capability of sending information for multiple TC reports.
3	(Reserved for future use.)

3.4.4.9.7 Other Capability Codes

Other capability codes are expected to be defined in later versions of this MASPS.

3.4.4.10 Operational Mode (OM) Parameters

Operational Mode (OM) codes are used to indicate the current operational modes of transmitting ADS-B participants. Specific operational mode codes are described in §3.4.4.10.1 to §3.4.4.10.4 below.

3.4.4.10.1 TCAS/ACAS Resolution Advisory Active Flag

A transmitting ADS-B participant shall (R2.xx) set the TCAS/ACAS Resolution Advisory Active Flag to ONE in the messages that it transmits to support the MS report so long as a TCAS II or ACAS resolution advisory is in effect. At all other times, the transmitting ADS-B participant shall (R3.xx) set the TCAS/ACAS Resolution Advisory Active Flag to ZERO.

Note: This field is also contained in the Status Change (SC) Report (§3.4.6). A change in the value of this field will trigger the transmission of messages supporting the SC report (§3.4.6.1).

3.4.4.10.2 IDENT Switch Active Flag

The "IDENT Switch Active" Flag is a one-bit OM code that is activated by an IDENT switch. Initially, the "IDENT switch active" OM code shall (R3.xx-A) be ZERO. Upon activation of the IDENT switch, this flag shall (R3.xx-B) be set to ONE for a period of 18 ± 1 seconds; thereafter, it shall (R3.xx-C) be reset to ZERO.

Note: This MASPS does not specify the means by which the "IDENT Switch Active" flag is set. That is left to lower-level documents, such as the MOPS for a particular ADS-B data link.

3.4.4.10.3 Requesting ATC Services Flag

The "Requesting ATC Services" flag is a one-bit OM code. When set to ONE, this code shall (R3.xx) indicate that the transmitting ADS-B participant is requesting to be provided with ATC services; otherwise this flag should be set to ZERO.

Note: This MASPS does not specify the means by which the "Requesting ATC Services" flag is set. That is left to lower-level documents, such as the MOPS for a particular ADS-B data link.

3.4.4.10.4 Other Operational Mode Codes

Other operational mode (OM) codes are expected to be defined in later versions of this MASPS.

3.4.4.11 Navigation Accuracy Category for Position (NAC_P) Field

The Navigation Accuracy Category for Position (NAC_P, §2.1.2.13) is reported so that surveillance applications may determine whether the reported position has an acceptable level of accuracy for the intended use. The NAC_P field in the MS report is a 4-bit field which shall (R3.xx) be encoded as described in Table 2.1.2.13 in §2.1.2.13 above.

Note: This field is also contained in the Status Change (SC) Report (§3.4.6). A change in the value of this field will trigger the transmission of messages supporting the SC report (§3.4.6.1).

3.4.4.12 Navigation Accuracy Category for Velocity (NAC_V) Field

The Navigation Accuracy Category for Velocity (NAC_V, §2.1.2.14) is reported so that surveillance applications may determine whether the reported velocity has an acceptable level of accuracy for the intended use. The NAC_V field in the MS report is a 3-bit field which shall (R3.xx) be encoded as described in Table 2.1.2.14 in §2.1.2.14 above.

Note: This field is also contained in the Status Change (SC) Report (§3.4.6). A change in the value of this field will trigger the transmission of messages supporting the SC report (§3.4.6.1).

3.4.4.13 Surveillance Integrity Level (SIL) Field

The SIL field in the MS report is a 2-bit field which shall (R3.xx) be coded as described in Table 2.1.2.15 in §2.1.2.15 above.

Note: This field is also contained in the Status Change (SC) Report (§3.4.6). A change in the value of this field will trigger the transmission of messages supporting the SC report (§3.4.6.1).

3.4.4.14 (Reserved for) BAQ Field

A 2-bit field in the MS Report is reserved for future use as a "Barometric Altitude Quality" field. In the current version (DO-242A) of this MASPS, the "Reserved for Barometric Altitude Quality" field shall (R3.xx) be ZERO.

Note: A possible future encoding of the BAQ field is described in §2.1.2.16 in Section 2 above.

3.4.4.15 NIC_{baro} Field

The NIC_{baro} field in the MS report is a one-bit flag that indicates whether or not the barometric pressure altitude provided in the State Vector Report has been cross-checked against another source of pressure altitude. A transmitting ADS-B participant shall (R3.xx-A) set NIC_{baro} to ONE in the messages that it sends to support the MS report only if there is more than one source of barometric pressure altitude data and cross-checking of one altitude source against the other is performed so as to clear the "barometric altitude valid" flag in the SV report if the two altitude sources do not agree. Otherwise, it shall (R3.xx-B) set this flag to ZERO.

3.4.4.16 True/Magnetic Heading Flag

The True/Magnetic Heading Flag in the Mode-Status report is a one-bit field which shall (R3.xx) be ZERO to indicate that heading is reported referenced to true north, or ONE to indicate that heading is reported referenced to magnetic north.

3.4.4.17 Vertical Rate Type Field

The Primary Vertical Rate Type field in the MS report is a one-bit flag which shall (R3.xx) be ZERO to indicate that the vertical rate field in the SV report 3.4.3.16 holds the rate of change of barometric pressure altitude, or ONE to indicate that the vertical rate field holds the rate of change of geometric altitude.

3.4.4.18 (Reserved for) Flight Mode Specific Data Field

A 3-bit field in the MS Report is reserved for future use as a "Flight Mode Specific Data" field. In the current version (DO-242A) of this MASPS, the "Reserved for Flight Mode Specific Data" field shall (R3.xx) be ZERO.

3.4.5 On-Condition Reports

The following paragraphs (§3.4.6 to §3.4.9) describe various On Condition (OC) reports. The OC reports are those for which messages are not transmitted all the time, but only when certain conditions are satisfied. Those OC report types currently defined are as follows:

SC: Status Change (SC) report (§3.4.6).

ARV: Air Referenced Velocity (ARV) Report (§3.4.7).

TS: Target State (TS) Report (§3.4.8).

TC+0, TC+n: Trajectory Change (TC) Reports (§3.4.9).

Other On-Condition reports may be defined in future versions of this MASPS. Examples of such reports are to be found in Appendix M.

3.4.6 Status Change (SC) Report

Note: While this version of the MASPS defines the format of this report and conditions which trigger its broadcast, update requirements of this report are to be defined in a future revision of this MASPS.

The Status Change (SC) report provides rapid update of time-critical information in the Mode Status and Trajectory Change reports. Table 3.4.6 lists the report elements. Messages to support this report will be broadcast when one or more of its elements change from their last communicated value in either the MS and TC reports. Those elements are indicated in the MS and TC definition tables (§3.4.4, and §3.4.9, respectively).

Table 3.4.6: Status Change (SC) Report Definition.

	SC Elem. #	Contents [Resolution or # of bits]		Reference Section	Notes
ID	1	Participant Address	[24 bits]	2.1.2.2.2.1	
	2	Address Qualifier	[4 bits]	2.1.2.2.2.2	
TOA	3	Time of Applicability	[1 s resolution]	3.4.6.3	
TCAS Status	4a	TCAS Installed and operational	[1 bit]	3.4.4.9.2	1
	4b	ACAS/TCAS resolution advisory active	[1 bit]	3.4.4.10.1	1
SV Quality	5a	Nav. Acc. Category for Position (NAC_P)	[4 bits]	3.4.4.11	1
	5b	Nav. Acc. Category for Velocity (NAC_V)	[3 bits]	3.4.4.12	1
	5c	Surveillance Integrity Level (SIL)	[2 bits]	3.4.4.13	1
TC Report Management	6a	Current TC Report Cycle Number	[2 bit]	3.4.9.5	2
	6b	TC Report Management Indicator	[3 bits]	3.4.9.6	2
Other	7	Reserved for Future Growth	[16 bits]		

Notes for Table 3.4.6:

1. *These SC report elements also reside in the Mode Status report (§3.4.4). Changes in any of their values from those previously broadcast in Mode Status reports trigger the transmission of messages supporting the SC report (§3.4.6.1).*

2. *These SC report elements also reside in the Trajectory Change report (§3.4.9). Changes in any of their values from those previously broadcast in Trajectory Change reports trigger the transmission of messages supporting the SC report (§3.4.6.1).*

3.4.6.1 Conditions for Transmitting the SC Report Information

Messages to support the SC report will be broadcast when one or more of its elements change from their last communicated value in either the MS and TC reports. This report will be broadcast for a time period to be defined in a future revision of this MASPS.

3.4.6.2 SC Report Update Requirements

Note: Specific report update rate and message transmission duration requirements for the SC report are deferred to a future version of this MASPS. However, it is recommended that the SC report should be updated at a rate equal to the State Vector report as defined in Table 3-4(a). This update rate should be maintained for a time period of at least twice the maximum update interval of either the Mode Status or Trajectory Change report, dependant upon which field has had a change in its value triggering the SC report.

3.4.6.3 Time of Applicability (TOA) Field for SC Report

The time of applicability relative to local system time shall (R3.42) be updated with every SC report update.

3.4.7 Air Referenced Velocity (ARV) Report

The Air Referenced Velocity (ARV) report contains velocity information that is not required from all airborne ADS-B transmitting participants, and that may not be required at the same update rate as the position and velocity elements in the SV report. Table 3.4.7 lists the elements of the ARV Report.

Table 3.4.7: Air Referenced Velocity (ARV) Report Definition.

	ARV Elem. #	Contents [Resolution or # of bits]		Reference Section	Notes
ID	1	Participant Address	[24 bits]	2.1.2.2.2.1	
	2	Address Qualifier	[4 bits]	2.1.2.2.2.2	1
TOA	3	Time of Applicability	[1 s resolution]	3.4.7.3	
Airspeed	4a	Airspeed	[1 knot or 4 knots]	3.4.7.4	
	4b	Airspeed Type and Validity	[2 bits]	3.4.7.5	
Heading	5a	Heading while airborne	[1 degree]	3.4.7.6	2
	5b	Heading Valid	[1 bit]	3.4.7.7	

Notes for Table 3.4.7:

1. *The minimum number of bits required by this MASPS for the Address Qualifier field is just one bit. However, when ADS-B is implemented on a particular data link, more than one bit may be required for the address qualifier if that data link supports other services in addition to the ADS-B service. The number of bits shown in the table for the Address Qualifier field is 4 only because experience in encoding that field in MOPS for particular ADS-B data links seems to indicate that 4 bits is sufficient.*

2. *The heading reference direction (true north or magnetic north) is given in the MS report (§3.4.4).*

3.4.7.1 Conditions for Transmitting ARV Report Elements

An airborne ADS-B participant of equipage class A1, A2 or A3 shall (R3.xx) transmit messages to support the ARV report when a period of 24 seconds has elapsed without the receipt of ground-referenced velocity information from the own-ship navigation equipment. (24 seconds is the maximum coast interval for SV reports.)

Notes:

1. *Airspeed and heading can be used by surveillance systems as a temporary replacement for ground-referenced velocity (N-S and E-W velocity, or alternately ground speed and ground track angle). The condition stated above for transmitting ARV report information is based on that use of the ARV information.*

2. *Additional uses of the ARV report are anticipated for future applications such as in-trail spacing, separation assurance when the transmitting aircraft is being controlled to an air-referenced heading, and for precision turns. For example, ARV report information allows wind conditions encountered by the transmitting aircraft to be derived. Current heading also provides a consistent reference when the aircraft is being controlled to a target heading. Such anticipated uses for ARV information are described in Appendix Q.*

3. *Such additional uses will be associated with additional conditions for transmitting messages to support the ARV report. It is anticipated that when the requirements for such future applications are better understood, that additional conditions for transmitting the ARV report information may be included in a future revision of this MASPS.*

3.4.7.2 ARV Report Update Requirements

When the condition of §3.4.7.1 is met, messages to support the ARV report shall (R3.xx) be transmitted at a rate sufficient that the ARV report is updated at the same rate as the SV report.

3.4.7.3 Time of Applicability (TOA) Field for ARV Report

The time of applicability relative to local system time shall (R3.xx) be updated with every Air-Referenced Velocity report update.

3.4.7.4 Airspeed Field

Reported airspeed ranges shall (R3.xx) be 0-4000 knots airborne. Airspeeds of 600 knots or less shall (R3.xx) be reported with a resolution of 1 knot or finer. Airspeeds between 600 and 4000 knots shall (R3.xx) be reported with a resolution of 4 knots or finer.

3.4.7.5 Airspeed Type and Validity

The Airspeed Type and Validity field in the ARV report is a 2-bit field that shall (R3.xx) be encoded as specified in Table 3.4.7.5.

Table 3.4.7.5: Airspeed Type Encoding

Airspeed Type	Meaning
0	Airspeed Type Field Not Valid
1	True Airspeed (TAS)
2	Indicated Airspeed (IAS)
3	Mach

3.4.7.6 Heading While Airborne Field

An aircraft's heading (§2.1.2.9) is reported as the angle measured clockwise from the reference direction (magnetic north or true north) to the direction in which the aircraft's nose is pointing. If an ADS-B participant broadcasts messages to support ARV reports, and heading is available to the transmitting ADS-B subsystem, then it shall (R2.xx) provide heading in those messages. Reported heading range shall (R3.xx) cover a full circle, from 0 degrees to (almost) 360 degrees. The heading field in ARV reports shall (R3.xx) be communicated and reported with a resolution at least as fine as 1 degree of arc.

Note: The reference direction for heading (true north or magnetic north) is reported in the Mode-Status report §3.4.4 above).

3.4.7.7 Heading Valid Field

The "Heading Valid" field in the ARV report shall (R3.xx) be ONE if the "Heading While Airborne" field contains valid heading information, or ZERO if that field does not contain valid heading information.

3.4.8 Target State (TS) Report

The Target State (TS) Report provides information on the horizontal and vertical targets for the active flight segment. Table 3.4.8 lists the elements of this report.

Table 3.4.8: Target State (TS) Report Definition.

	TSR Elem. #	Contents [Resolution or # of bits]		Reference Section
ID	1	Participant Address	[24 bits]	2.1.2.2.2.1
	2	Address Qualifier	[4 bits]	2.1.2.2.2.2
TOA	3	Time of Applicability	[1 s resolution]	3.4.8.3
Horizontal Short Term Intent	4a	Horizontal Data Available and Horizontal Target Source Indicator	[2 bits]	3.4.8.4
	4b	Target Heading or Track Angle	[1 degree]	3.4.8.5
	4c	Target Heading/Track Indicator	[1 bit]	3.4.8.6
	4d	(Reserved for Heading/Track Capability)	[1 bit]	3.4.8.7
	4e	Horizontal Mode Indicator	[1 bit]	3.4.8.8
	4f	(Reserved for Horizontal Conformance)	[1 bit]	3.4.8.9
Vertical Short Term Intent	5a	Vertical Data Available and Vertical Target Source Indicator	[2 bits]	3.4.8.10
	5b	Target Altitude	[100 ft]	3.4.8.11
	5c	Target Altitude Type	[1 bit]	3.4.8.12
	5d	Target Altitude Capability	[2 bits]	3.4.8.13
	5e	Vertical Mode Indicator	[1 bit]	3.4.8.14
	5f	(Reserved for Vertical Conformance)	[1 bit]	3.4.8.15
Reserved		(Reserved for future growth)	[4 bits]	

3.4.8.1 Conditions for Transmitting TS Report Information

<< I believe these two requirements are redundant. Shouldn't we remove the first sentence below??>>

An airborne ADS-B participant of equipage class A2 or A3 shall (R3.xx) transmit messages to support the TS report when the flight director or autopilot is engaged consistent with the axis of the target being sent. The class A2 or A3 participant shall (R3.xx) transmit these messages when either of the following conditions is met:

a. Target altitude or an acceptable substitute for target altitude (§3.4.8.11) is available from the automation system; or

b. Target heading or target track is available from the automation system.

3.4.8.2 TS Report Update Requirements

The nominal update interval for TS Report information is specified in §3.3.3.1.4 and Table 3-4(c).

The higher "state change" update interval requirements specified for TS Report information in §3.3.3.1.4 and Table 3-4(c) shall (R.3.xx) be met whenever there is a change in the value of any of the following TS report fields:

- Horizontal Data Available and Horizontal Source Indicator (§3.4.8.4);
- Target Heading or Track Angle (§3.4.8.5);
- Target Heading/Track Indicator (§3.4.8.6);
- Vertical Data Available and Vertical Source Indicator (§3.4.8.10);
- Target Altitude (§3.4.8.11).

3.4.8.3 Time of Applicability (TOA) field for TS Report

The time of applicability relative to local system time shall (R3.xx) be updated with every Target State report update.

3.4.8.4 Horizontal Data Available and Horizontal Target Source Indicator Field

The Horizontal Data Available and Horizontal Target Source Indicator field is a 2-bit field in the TS Report and will have a value of ZERO to indicate that no valid horizontal Target State data is available. Non-ZERO values will be used to provide the source of target heading or track angle information. An aircraft system is considered to be the target source when a change to that system's settings (for the current operational mode) would cause the aircraft trajectory to change.

The Horizontal Data Available and Horizontal Target Source Indicator field shall (R3.xx) be encoded as specified in Table 3.4.8.4 below.

Table 3.4.8.4: Horizontal Data Available and Horizontal Target Source Indicator Field Values

Value	Meaning
0	No valid horizontal Target State data is available.
1	Autopilot control panel selected value, such as Mode Control Panel (MCP) or Flight Control Unit (FCU)
2	Maintaining current heading or track angle (e.g., autopilot mode select)
3	FMS/RNAV system (indicates track angle specified by leg type)

In cases where the aircraft is operated in a horizontal FMS/RNAV mode and the FMS/RNAV target track angle is the same as the autopilot control panel selected track angle, the Horizontal Data Available and Horizontal Target Source Indicator shall (R3.xx) be set to "FMS/RNAV system."

3.4.8.5 Target Heading Or Track Angle Field

The "Target Heading or Track Angle" field in the TS Report contains either the transmitting aircraft's *target heading* or its *target track angle*, depending on the value reported in the "Heading or Track Angle Indicator" field (§3.4.8.6).

- The target heading is the aircraft's intended heading after turn completion or its current intended heading if in straight flight. Target heading is only provided if the aircraft is being controlled to a heading reference.
- The target track angle is the aircraft's intended track angle over the ground after turn completion or its current intended track angle if in straight flight. Target track angle is only provided if the aircraft is being controlled to a ground referenced track angle.

Target heading or track angle shall (R3.xx) be reported over the full range of all possible directions, 0° to almost 360°, expressed as an angle measured clockwise from a reference direction. (The reference direction for target heading or track angle is communicated in the MS report, paragraph above.) Target heading or track angle shall (R3.xx) be communicated and reported with a resolution at least as fine as one degree of arc.

3.4.8.6 Target Heading/Track Indicator Field

The orientation type (heading or track angle) is conveyed in the Target Heading/Track Indicator field of the TS Report. This field shall (R2.xx) be ZERO to indicate that the "Target Heading or Track Angle" field conveys target heading, or ONE to indicate that it conveys target track angle. The reference direction (true north or magnetic north) is conveyed in the MS report.

3.4.8.7 (Reserved for) Heading/Track Capability Field

A one-bit field is reserved in the TS Report for future use as a "Heading/Track Capability" field. This field will indicate whether or not the transmitting aircraft has the capability to provide the horizontal guidance target. In the current version (DO-242A) of the MASPS, the "Reserved for Heading/Track Capability" field shall (R3.xx) be ZERO.

3.4.8.8 Horizontal Mode Indicator

The Horizontal Mode Indicator element of the TS Report is a one-bit field that reflects the aircraft's state relative to the target heading or track angle.

The Horizontal Mode Indicator shall (R3.xx) be ZERO to indicate the "acquiring" mode, or ONE to indicate the "capturing or maintaining" mode.

3.4.8.9 (Reserved for) Horizontal Conformance

A one-bit field in the TS Report is reserved for future use as a "Horizontal Conformance" flag. In the current version (DO-242A) of this MASPS, the "Reserved for Horizontal Conformance" field shall (R3.xx) be ZERO.

3.4.8.10 Vertical Data Available and Vertical Target Source Indicator Field

Vertical Data Available and Vertical Target Source Indicator field is a 2-bit field in the TS Report and will have a value of ZERO to indicate that no valid vertical Target State data is available. Non-ZERO values will be used to provide the source of target altitude information. An aircraft system is considered to be the target source when a change to that system's settings (for the current operational mode) would cause the aircraft trajectory to change.

The Vertical Data Available and Vertical Target Source Indicator field shall (R3.xx) be encoded as specified in Table 3.4.8.10 below.

Table 3.4.8.10: Vertical Data Available and Vertical Target Source Indicator Field Values

Value	Meaning
0	No valid vertical Target State data is available.
1	Autopilot control panel selected value, such as Mode Control Panel (MCP) or Flight Control Unit (FCU)
2	Holding Altitude
3	FMS/RNAV system

In cases where the aircraft is operated in a vertical FMS/RNAV mode and the FMS/RNAV target altitude is the same as the autopilot control panel selected altitude, the Vertical Data Available and Vertical Target Source Indicator shall (R3.xx) be set to "FMS/RNAV system."

3.4.8.11 Target Altitude Field

Target altitude is the aircraft's next intended level flight altitude if in a climb or descent or its current intended altitude if commanded to hold altitude. Target altitude shall (R3.xx) be represented as the operational altitude recognized by the transmitting aircraft's guidance system.

For aircraft unable to determine target altitude as defined above, the Target Altitude field may contain a substitute value. If a substitute value is provided, that value shall (R3.xx) be consistent with the aircraft's target altitude capability as listed in Table 3.4.8.13.

In order to ensure a consistent reference for target altitude, all aircraft must follow standard conventions by using barometric corrected altitude (altimeter set to local setting) below the transition level and pressure altitude (altimeter set to 29.92 in Hg, or 1013.25 hPa) above the transition level. Target altitude shall (R3.xx) be provided with a range from –1000 ft to +100,000 feet and shall (R3.xx) have a resolution of 100 feet. be communicated and reported with a resolution of 100 feet or finer.

Note: The 100-foot resolution for target altitude was chosen because that is the resolution supported by the Mode Control Panel (MCP) or Flight Control Unit (FCU) equipment in use on commercial aircraft. Since target altitude can only be input in multiples of 100 feet, there is no need for a finer resolution for the encoding of target altitude. This MASPS requirement does not, of course, dictate how target altitude will be encoded on a particular ADS-B data link.

3.4.8.12 Target Altitude Type Field

The target altitude type field in the Target State Report is a one-bit field that indicates whether the target altitude is a barometric pressure altitude or flight level (used for target altitudes above the transition level between altitude types), or a locally corrected altitude (used for target altitudes below the transition level). The Target Altitude Type shall (R3.xx) be encoded as specified in Table 3.4.8.12 below.

Table 3.4.8.12: Target Altitude Type Values.

Value	Meaning
0	Pressure Altitude ("Flight Level") – target altitude is above transition level
1	Baro-Corrected Altitude ("MSL") – target altitude is below transition level

3.4.8.13 Target Altitude Capability Field

Alternate values of target altitude may be provided by aircraft unable to support the general definition of target altitude. The target altitude capability is a two-bit field that describes the potential values occupying the target altitude field. The target altitude capability field shall (R3.xx) be encoded as shown in Table 3.4.8.13 below.

Table 3.4.8.13: Target Altitude Capability Field Values

Value	Meaning
0	Capability for holding altitude only
1	Capability for either holding altitude or for autopilot control panel selected altitude
2	Capability for either holding altitude, for autopilot control panel selected altitude, or for any FMS/RNAV level-off altitude
3	Reserved

3.4.8.14 Vertical Mode Indicator

The Vertical Mode Indicator reflects the aircraft's position relative to the target altitude.

The Vertical Mode Indicator shall (R3.xx) be ZERO to indicate the "acquiring" mode, or ONE to indicate the "capturing" or "maintaining" mode.

3.4.8.15 (Reserved for) Vertical Conformance Field

A one-bit field is reserved in the TS Report for future use as a "Vertical Conformance" flag. In ADS-B systems that conform to this version of this MASPS (DO-242A), the "Reserved for Vertical Conformance" field shall be ZERO.

3.4.9 Trajectory Change (TC+0, TC+n) Reports

Trajectory Change (TC) Reports contain long-term intent information providing strategic path information for path prediction and other functions, such as conformance monitoring. This information can include waypoint constraints, TCPs, and their connecting flight segments.

Table 3.4.9 shows the overall structure for TC Reports. The structure shown here can accommodate multiple TC reports, and to provide for additional fields as more types and subtypes of TC reports are developed for later versions of this MASPS.

Table 3.4.9: Trajectory Change (TC) Report Definition.

	TC Report Elem. #	Contents [Notes] [Resolution or # of Bits]	Needed Only For TC+0 Reports	Reference Section	Notes
ID	1	Participant Address [24 bits]		2.1.2.2.2.1	
	2	Address Qualifier [4 bits]		2.1.2.2.2.2	
TOA	3	Time of Applicability [1 s resolution]		3.4.9.3	
TC Report #	4	(Reserved for TC Report Sequence Number) [2 bits]		3.4.9.4	1
TC Report Version	5a	TC Report Cycle Number [2 bits]		3.4.9.5	1, 2
	5b	TC Management Indicator (TCMI) [3 bit]	•	3.4.9.6	2
TTG	6	Time To Go [4 s resolution]		3.4.9.7	
Horizontal TC Report Information	7a	Horizontal Data Available and Horizontal TC Type [4 bits]		3.4.9.8	
	7b	TC Latitude [700 m or better]		3.4.9.9	3,4
	7c	TC Longitude [700 m or better]		3.4.9.10	3,4
	7d	Turn Radius [700 m or better]		3.4.9.11	3,4
	7e	Track to TCP [1 degree]		3.4.9.12	3
	7f	Track from TCP [1 degree]		3.4.9.13	3
	7g	(Reserved for Horizontal Conformance) [1 bit]	•	3.4.9.14	3
	7h	Command or Planned Trajectory (Horizontal) [1 bit]		3.4.9.15	
Vertical TC Report Information	8a	Vertical Data Available and Vertical TC Type [4 bits]		3.4.9.16	
	8b	TC Altitude [100 ft resolution]		3.4.9.17	
	8c	TC Altitude Type [1bit]		3.4.9.18	
	8d	(Reserved for Altitude Constraint Type) [2 bits]		3.4.9.19	
	8e	(Res. for Able/Unable Altitude Constraint) [1 bit]	•	3.4.9.20	
	8f	(Reserved For Vertical Conformance) [1 bit]	•	3.4.9.21	
	8g	Command or Planned Trajectory (Vertical) [1 bit]		3.4.9.22	

Notes for Table 3.4.9:

1. *This MASPS (DO-242A) provides for up to four TC Reports.*

2. *Changes to the values of these elements will be communicated in a Status Change (SC) on-condition report (§3.4.6).*

3. *The value of the Horizontal Data Available and Horizontal TC Type element, determines (a) whether this element is required in the TC report and (b) the element's required resolution (weight of the LSB in reporting this TC report element). See §3.4.9.8 below.*

4. *Finer resolution than 0.38 NM (700 m) may be required for non-precision approach and precision approach/departure applications. It is expected that new TC report types will be defined for applications with finer resolution requirements.*

3.4.9.1 Conditions for Transmitting Trajectory Change Report Information

The following conditions are necessary requirements to initiate generation of TC reports:

1. The transmitting aircraft shall have an autopilot or flight director engaged and have access to active FMS/RNAV planning data or next target altitude. If the aircraft only supports a single axis autopilot or flight director, then the complementary axis data fields for TC reports are marked “not available”.

2. Each TC report shall have an associated, stable TTG value generated by the FMS/RNAV system or by extrapolation from current state vector and intent information available at the transmitting ADS-B subsystem. A TTG value is considered “stable” if the estimated TTG value based on previous information is consistent with the current TTG value, i.e. the difference between the previous TTG estimate updated for delta elapsed time and the current TTG estimate is less than some threshold value. (Threshold values for determining stability of TTG will be determined in lower level documentation.)

Given that the above conditions are satisfied, and any TC+0 report previously generated is not currently valid, an A2 level system shall (R3.xx) initiate broadcast of a TC+0 report when the aircraft is within 4 minutes TTG to the trajectory change described in that TC+0 report, or as otherwise needed to meet the acquisition range requirements for A2 equipage as specified in Table 3-4(c). Similarly, an A3 level system shall (R3.xx) initiate broadcast of a TC+0 report when the aircraft is within 8 minutes TTG to the trajectory change described in that report, or as otherwise needed to meet the acquisition range requirements for A3 equipage as specified in Table 3-4(c). The TC cycle number shall then (R3.xx) be incremented in the mode status report and in subsequent TC+0 broadcast reports, to reflect broadcast of current intent data. For most TC types, the active flight segment is sequenced when the aircraft passes the transition point whose latitude and longitude are given in the TC report or captures the current target altitude. However, for Fly-By turns, the TC latitude and longitude are for a point in the middle of the turn segment, and the active flight segment (turn maneuver) is not completed until the target track in the TC report, i.e. track-from value has been captured. Normally, this condition is signaled by the Horizontal Mode Indicator. If the TS report target track is not available, then a test shall be performed on current state vector components to verify capture of the track-from value as a condition for sequencing the turn maneuver. In either event, the Fly-By turn shall be sequenced if more than 2 minutes has elapsed since the time of TCP sequencing

In the event that the active flight segment is sequenced, or a major change in intent is detected such that TC+0 report data is no longer valid, the aircraft broadcasting TC+0 reports shall (R3.xx) increment the TC report cycle number (modulo 4) for subsequent mode status and TC report broadcasts, and begin broadcasting TC+0 report flight segment and TCP data if the conditions (1) and (2) above are satisfied. The aircraft must broadcast the TC+0 report data at a rate sufficient to achieve range reception requirements shown in Table 3-4(c). If no intent data is available for subsequent TC+0 broadcast, the broadcast of an incremented TC report cycle number in the Mode Status report is sufficient for receiving aircraft to mark all previous TC report intent data from that aircraft as invalid or not available.

Notes:

1. *In the future, the TC+0 report transition flag will probably be used to signal A3 systems when it is possible to 'roll over' previous TC +1 report data into the TC+0 report slot, and when it is necessary to delete or mark invalid previously broadcast TC+n report data.*

2. *Simple changes in estimated values such as estimated altitude at a waypoint are not considered major changes in intent. Major changes of intent typically would result in TC report resequencing or would involve changes in TCP type associated with a pilot input, e.g. a "direct to" clearance that bypasses one or more current TCP points.*

3. *For level A3 systems, it is important to achieve continuity of intent as the aircraft approaches the end of the current flight segment. An A3 system should initiate broadcast of a TC+1 report when suitable intent is available and the aircraft is within 8 minutes TTG to TCP+1, or whenever TTG to TCP+0 is less than 2 minutes if TTG to TCP+1 exceeds the 8 minute threshold. Other conditions for broadcasting TC+1 reports and more remote TCPs are under development, and are summarized in Appendix N.*

4. *A TC report for any trajectory change other than the active trajectory change will not be required if the TTG to that trajectory change exceeds 20 minutes. For example, if the TTG to the next trajectory change waypoint is 26 minutes, then no TC reports beyond the next waypoint (TC+0) are required. This limitation would prevent indiscriminate broadcast of TC reports that are not operationally relevant.*

3.4.9.2 TC Report Update Requirements

The nominal update interval for TC+0 information is specified in §3.3.3.1.4 and Table 3-4(c).

The higher "state change" update interval requirements specified for TC Report information in §3.3.3.1.4 and Table 3-4(c) shall (R.3.xx) be met whenever there is a change in the TC Report Cycle Number and/or TC Report Management Indicator (RMI) fields of the TC report (§3.4.9.5 and §3.4.9.6, respectively).

Note: Update intervals for subsequent TC reports (TC+1,…,TC+n) are under development, but are expected to be a function of TTG and may have less stringent requirements on reception probability. See Appendix N for a summary of multiple TC report management guidelines.

3.4.9.3 Time of Applicability (TOA) Field for TC Report

The time of applicability relative to local system time shall (R3.xx) be updated with every TC report update.

3.4.9.4 (Reserved for) TC Report Sequence Number

The TC Report Sequence Number is a sequence number for the set of Trajectory Change Reports that describe a target's current intent; it is "n" in the expression "TC+n". The current TC ("TC+0") is the trajectory change report that describes the next point (Trajectory Change Point, TCP) at which the aircraft's trajectory will change. "TC+1" is a Trajectory Change report that describes the next trajectory change after the one described in the TC+0 report. And so on.

The "Reserved for TC Report Sequence Number" field in the TC report shall (R3.xx) contain a value of ZERO for this version of the MASPS.

3.4.9.5 TC Report Cycle Number

The TC Report Cycle Number is a 2 bit field in the TC and Status Change reports. This field indicates a current "version number" for the numbering of the TC reports. The TC Report Cycle Number is a means for indicating when the trajectory change intent information previously broadcast is current and relevant, and when TC report elements previously broadcast need to be deleted or resequenced.

The TC Report Cycle Number shall (R3.xx) increment when any of the following conditions are met:

- A change in TC estimated time of arrival (i.e., TOA+TTG) of greater than 30 seconds;
- A change in the Horizontal Data Available and Horizontal TC Type (§3.4.9.8) field;
- A change in horizontal position greater than 2 NM from the position defined by TC Latitude and TC Longitude (§3.4.9.9 and §3.4.9.10, respectively);
- A change in the Command or Planned Horizontal (§3.4.9.15) field;
- A change in the Vertical Data Available and Vertical TC Type (§3.4.9.16) field;
- A change in TC Altitude (§3.4.9.17) – if the Vertical TC Type (§3.4.9.16) is not Estimated Altitude - of more than 100 feet;
- A change in the Command or Planned Vertical (§3.4.9.22) field;

Note 1: TC report resequencing will be a future condition on which TC Report Cycle Number will be incremented.

The TC Report Cycle Number shall (R3.xx) be a number in the range from 0 to 3 that is incremented (modulo 4) each time the numbering of TC reports changes. That is, the TC report cycle number is incremented from 0 to 1, then from 1 to 2, then from 2 to 3, and then from 3 back to 0.

Note 2: This field is also contained in the Status Change (SC) Report (§3.4.6). A change in the value of this field will trigger the transmission of messages supporting the SC report (§3.4.6.1).

3.4.9.6 Trajectory Change Management Indicator (TCMI)

The Trajectory Change Management Indicator (TCMI) is a three-bit field in the TC and Status Change reports. This field is used in the current MASPS to indicate whether or not the TC+0 data is valid. ~~This field is used in the current MASPS to indicate whether to retain and refresh previous TC+0 report data, or to mark current TC+0 reports as invalid.~~ TC Report Management actions based on the values of TCMI and TC Cycle Number are described in §3.4.9.23.

The TC Report Management Indicator shall (R3.xx) be given a value of 0 if any of the following conditions are met:

a. if valid TC+0 data being broadcast is from the same TC+0 report for which there have been messages previously broadcast (in which case it has a matching TC Cycle Number);

b. if valid TC+0 data is being sent for a new TC+0 report (in which case the TC Cycle Number has been incremented from the previous TC+0 report).

The TC Report Management Indicator shall (R3.xx) be given a value from 1 if the TC+0 report data being broadcast is no longer valid and no new TC+0 reports are being generated.

TC report information shall (R3.xx) be considered invalid if any of the following conditions are met:

a. the current TC+0 report is not updated for a time period exceeding twice the required update interval for TC reports as specified in §3.3.3.1.4;

b. the end point of the current TC+0 report has been reached and no subsequent TC+0 reports are to be immediately issued.

Otherwise, TC report information shall (R3.xx-B) be considered valid.

Table 3.4.9.6: TC Report Management Indicator

TC Report Management Indicator	Meaning
0	~~Retain and Refresh Current TC+0 Report~~ Valid TC report data
1	~~Indicates Current TC+0 Report is Invalid~~ Valid TC report data
2 to 7	Reserved for future use

Notes:

1. *The values from 2 to 7 are reserved for multiple TC report management to be defined in future MASPS versions. Examples of multiple TC report management include resequencing of TC report, (i.e. refresh and rolling of TC+1 report data into TC+0 reports when current flight segment is sequenced) and the insertion and deletion of TC reports in-between existing TC reports corresponding to changes in the flight plan. (See Appendix N for further details on multiple TC report management.)*

2. *This field is also contained in the Status Change (SC) Report (§3.4.6). A change in the value of this field will trigger the transmission of messages supporting the SC report (§3.4.6.1).*

3.4.9.7 Time To Go (TTG) Field in TC Reports

The Time to Go (TTG) field in a TC report contains the estimated remaining flight time to the trajectory change described in that report. The TTG field shall (R3.xx) have a resolution of 4 seconds or better, and shall (R3.xx-A) have a range from –120 sec to +1200 sec (20 min), and shall (R3.xx-B) have a means to indicate a TTG value of greater than 20 minutes.

TTG is originally computed from ETA or estimated time of arrival at a waypoint as the time difference between the ETA point and the estimated time of applicability for ADS-B broadcasting. When TCP message data with TTG is received, coast time is set to zero, and TTG is referenced relative to the report Time of Applicability. If no further messages for that TCP are received at the next report time, then coast time is incremented and TTG is decremented by delta time of applicability, i.e. the report time, coast time and TTG are all updated relative to the current time of applicability. This process of TC report data 'refreshment' continues until an updated TCP message with TTG is received, or the coast time exceeds a threshold limit for data renewal and the TC report data is marked "not available", or the current flight segment is sequenced.

3.4.9.8 Horizontal Data Available and Horizontal TC Type

The horizontal trajectory change information given in TC reports varies according to the Horizontal TC Type, of the TC report, as indicated in Table 3.4.9.8 below.

The Horizontal Data Available and Horizontal TC Type will have a value of ZERO if valid horizontal TCP information is *not* available in the TC Report and have Non-ZERO values to indicate the horizontal TC Type. The Horizontal TC Type shall (R3.xx) be encoded as specified in the first column of Table 3.4.9.8. For each Horizontal TC Type listed in the first column of the table, consult the corresponding Figure, also referenced in that column of the table, for an illustration of the meaning of the data being reported for that TC type. For each Horizontal TC Type listed, the resolution of the TC report elements listed in the following columns shall (R3.xx) be at least as fine as indicated in the table, *except* that elements marked as "n/r" are not required to be reported in TC reports for that horizontal TC type.

Note: The bearing angle from the previous TC report or from the current state (for TCP+0) to the endpoint TCP may be reported in the Track-To-Trajectory-Change field for "Direct to Fix" and "Direct to Fly-By" TC report types.

Table 3.4.9.8: Horizontal TC Type Encoding and Horizontal TC Report Elements Required For Each Horizontal TC Type

Horizontal TC Type	Required Resolution (Weight of LSB in Report Element)			
	TC Latitude, TC Longitude	Turn Radius	Track Angle	
			To TCP	From TCP
(§3.4.9.8)	(§3.4.9.10)	(§3.4.9.11)	(§3.4.9.12)	(§3.4.9.13)
0: Data Not Available (note 1)	Horizontal TC Report Information Not Available			
1: Direct to Fix (DF) [Figure 3.4.9.8(a)]	700 m (0.38 NM)	n/r	1 degree	n/r
2: Geodesic Path to Fix, Course to Fix (CF) or Track to Fix (TF) [Figure 3.4.9.8(a)]	700 m (0.38 NM)	n/r	1 degree	n/r
3: CF or TF to Fly-By Turn [Figure 3.4.9.8(b)]	700 m (0.38 NM)	700 m (0.38 NM)	1 degree	1 degree
4: DF to Fly-By Turn [Figure 3.4.9.8(b)]	700 m (0.38 NM)	700 m (0.38 NM)	1 degree	1 degree
5. Radius to Fix (RF) Turn Transition [Figure 3.4.9.8(c)]	700 m (0.38 NM)	700 m (0.38 NM)	n/r	1 degree
6-15: Reserved (note 2)	Reserved for Definition in Future Versions of This MASPS			

Notes for Table 3.4.9.8:

1. *The value of ZERO for the Horizontal TC Type code is reserved to mean "Horizontal TC Data Not Available" so that a separate one-bit field is not needed.*

2. *Future versions of this MASPS may specify addition Horizontal TC types, with different requirements on the resolution of the horizontal TCR elements.*

Figure 3.4.9.8 (a) illustrates the meanings of the TC report fields that are reported for Horizontal TC types 1 and 2, which correspond to the TF, CF, and DF leg types (from DO-236A, §3.2.3.2, §3.2.3.9, and §3.2.3.8 respectively).

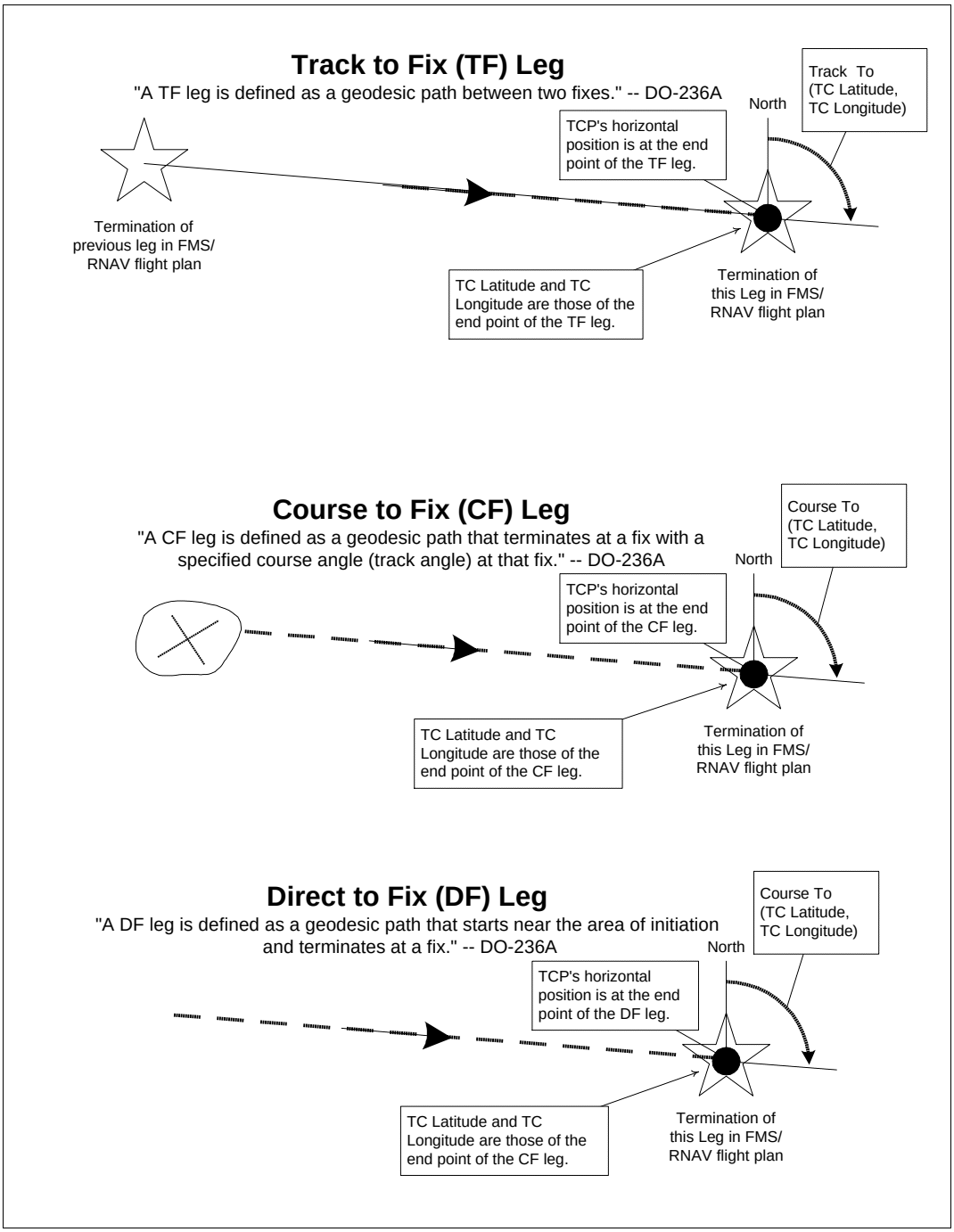

Figure 3.4.9.8 (a): Meaning of Fields for Horizontal TC Types 1 and 2.

Figure 3.4.9.8 (b) illustrates the meanings of the TC report fields that are reported for Horizontal TC types 3 and 4, which correspond to the TF, CF, and DF legs to Fly-By Transitions as described in DO-236A, §3.2.5.4.1.

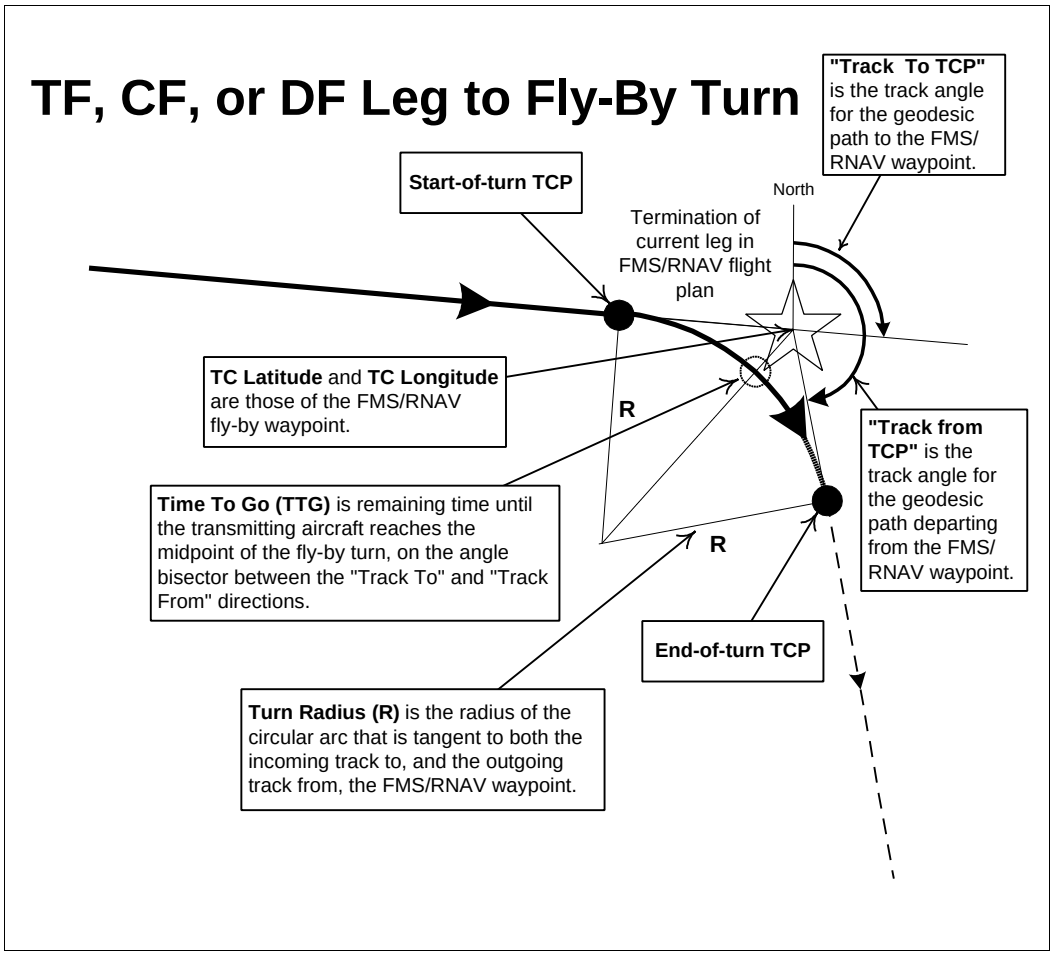

Figure 3.4.9.8 (b): Meaning of Fields for Horizontal TC Types 3 and 4.

Figure 3.4.9.8 (c) illustrates the meanings of the TC report fields that are reported for Horizontal TC type 5, which corresponds to the Radius to Fix (RF) leg type as described in DO-236A, §3.2.3.3.

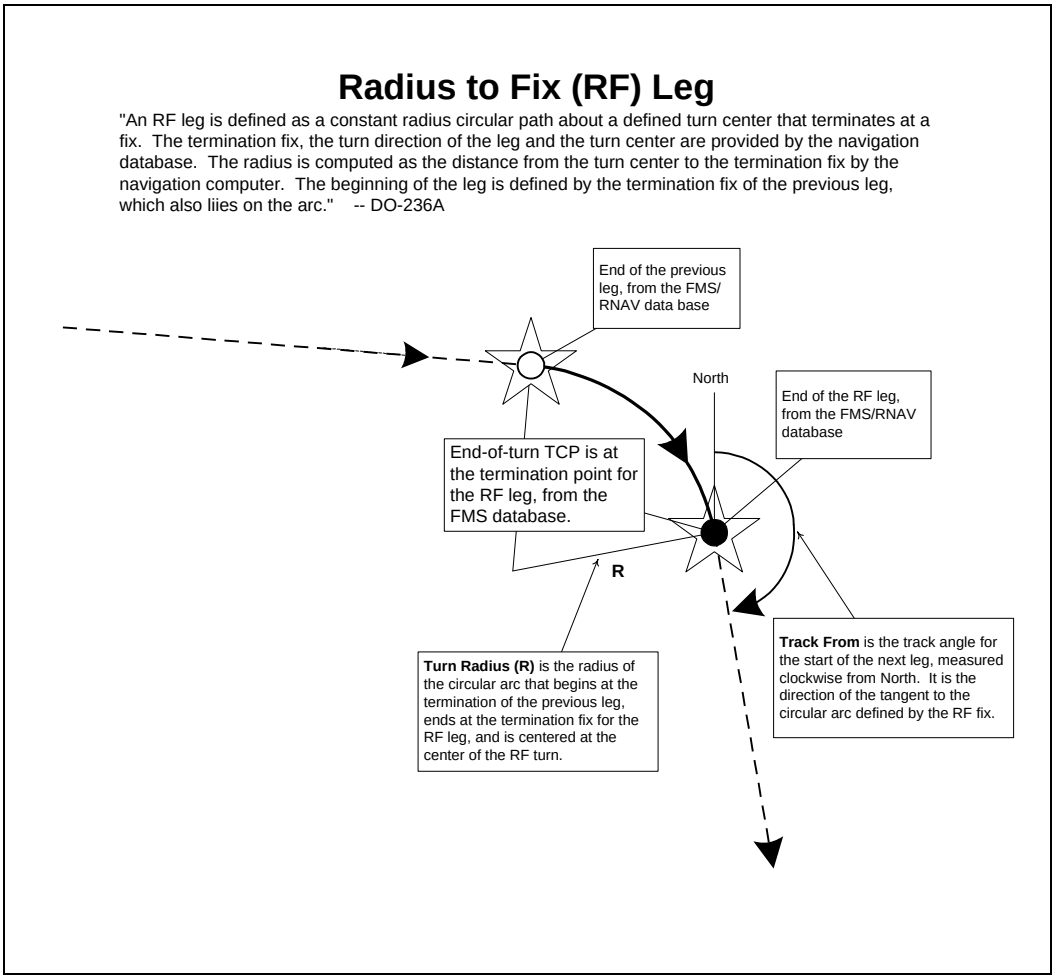

Figure 3.4.9.8 (c): Meaning of Fields for Horizontal TC Type 5.

3.4.9.9 TC Latitude

TC Latitude shall (R3.xx) be reported as WGS-84 latitude. TC horizontal position shall (R3.xx) be reported with the full range of possible latitudes (-90° to +90°). Resolution of TC latitude shall (R3.xx) be 700 m or finer for the horizontal TC types shown in Table 3.4.9.8.

3.4.9.10 TC Longitude

TC Longitude shall (R3.xx) be reported as WGS-84 longitude. TC horizontal position shall (R3.xx) be reported with the full range of possible longitudes (-180° to +180°). Resolution of TC longitude shall (R3.xx) be 700 m or finer for the horizontal TC types shown in Table 3.4.9.8.

3.4.9.11 Turn Radius

Turn radius in NM shall (R3.xx-A) be reported if available as an input to the ADS-B transmitting subsystem for horizontal TC types 3 and 4, i.e. when the TC report describes a Fly-By turn. For horizontal TC type 5 (radius to fix turns), turn radius in nautical miles shall (R3.xx-B) be reported as a mandatory TC report element, i.e. if turn radius is unavailable, then the horizontal TC report data fields should be marked not valid. Resolution of turn radius shall (R3.xx-C) be 700 m or finer when reported. The range of possible turn radius values is (0.0 to 28.6 NM).

Note: The maximum turn radius above is based on a maximum turn anticipation distance of 20 NM, a maximum track angle change of 70 degrees (for high altitude transitions), and an analytic relationship between turn radius, turn anticipation and track angle change (RNP RNAV MASPS, DO-236A, section 3.2.5.4.1), i.e. R = 20 / tan(70/2) ~ 28.6 NM. Turn radius values input to the ADS-B system larger than the maximum value will be truncated, and intent quality may be downgraded, e.g. reported as planned rather than command data.

3.4.9.12 Track to TCP

Track to TCP is the intended track angle for horizontal TC types 1 to 4 that specifies the inbound transition from the current position or from the endpoint of one flight segment to the next TC Report. Track-to may not be output on an avionics bus unless the horizontal leg type is a Course to Fix (CF) type, and should then be derived from information that is available on avionics buses, e.g. ARINC 702A trajectory bus. The track-to element is typically computed using the previous "From" (start point) waypoint and "To" (end point) waypoint as the track angle between the two waypoints. If the leg type is a Direct to Fix (DF) type, then the bearing from the current position to the endpoint TCP shall be used to represent track-to for the active flight segment, e.g. TC+0.

3.4.9.13 Track from TCP

Track from TCP is the intended track angle on completion of a horizontal turn segment (horizontal TC types 3 to 5) that specifies the outbound transition from the turn TC point, i.e. Fly-By point or Radius to Fix turn endpoint. Track from TCP is typically not available on an avionics bus and should be derived from the endpoint TCP and succeeding horizontal waypoint data. Track-from is computed as the track angle from the turn TCP point to the next waypoint.

Note: If both TC+0 and TC+1 report information are broadcast and TC+0 is a Fly-By or RF turn point, then track-from TC+0 is the same as track-to TC+1.

3.4.9.14 (Reserved for) Horizontal Conformance

A one-bit field is reserved in the Trajectory Change Report for future use as a "Horizontal Conformance" flag. In ADS-B systems that conform to this version (DO-242A) of this MASPS, the "Reserved for Horizontal Conformance" field shall (R3.xx) be ZERO.

3.4.9.15 Command or Planned Trajectory (Horizontal)

<< NEW TEXT TO BE PROVIDED BY RICHARD >>

The Horizontal Command/Planned flag is a one bit field that informs the data user about the reliability of horizontal TC report data. (For more details, see section 7 of Appendix N.) The bit field **shall (R3.xx)** be set to Zero for Planned trajectory segments, and set to One for Command trajectory segments. The default value for this field is Zero, i.e. the flag should indicate a Command trajectory only for the conditions specified below.

The horizontal Command/Planned flag is set based on the value of the TS report horizontal Target Source Indicator (TSI) (3.4.7.3.5). If the active flight segment is being flown in an autopilot mode, i.e. TSI = 0 or TSI=1, then all TC reports **shall (R3.xx)** broadcast the Planned flag. If the active flight segment is being flown in an FMS or RNAV mode, i.e. TSI=2, then all TC reports **shall (R3.xx)** broadcast the Command flag. If TS reports are not being issued, then all TC reports **shall (R3.xx)** broadcast the default Planned flag.

3.4.9.16 Vertical Data Available and Vertical TC Type

The Vertical Data Available and Vertical TC Type will have a value of ZERO if valid vertical TCP information is *not* available in the TC Report and have NON-ZERO values to indicate the vertical TC Type. The vertical trajectory change information given in TC Reports varies according to the vertical TC Type, as indicated in Table 3.4.9.16 below. The Vertical TC Type shall (R3.xx) be encoded as specified in the first column of Table 3.4.9.16.

Table 3.4.9.16: Vertical TC Report Elements For Each Vertical TC Type.

Value	Vertical TCP Type
0	Data Not Available
1	Unknown Vertical TC Type
2	Target Altitude
3	Reserved for Constraint Altitude
4	Estimated Altitude
5	Top of Climb (TOC)
6	Top of Descent (TOD)
7-15	Reserved

3.4.9.17 TC Altitude

The Trajectory Change Altitude in the TC report provides the altitude of the trajectory change point. The ADS-B system shall (R3.xx) support TC altitudes in the range from -1,000 feet to +100,000 feet. The resolution with which TC altitude is reported shall (R3.xx) be 100 feet.

3.4.9.18 TC Altitude Type

The TC Altitude Type in the TC report, is a one-bit field that indicates whether the TC altitude is a barometric pressure altitude or flight level (used for TCPs with altitudes above the local transition level between altitude types), or a locally corrected altitude (used for TCPs with altitudes below the local transition level). The TC Altitude Type shall (R3.xx) be encoded as specified in Table 3.4.9.18 below.

Notes:

1. *If the TC altitude type is unknown, then the vertical elements of the TC report should not be communicated or reported.*

2. *The default value of TC Altitude Type is ZERO for TCPs located in U.S. NAS airspace above 18,000 feet.*

Table 3.4.9.18: TCP Altitude Type Encoding.

Value	Meaning
0	Pressure Altitude ("Flight Level") – TCP above local transition level
1	Baro-Corrected Altitude ("MSL") – TCP below local transition level

3.4.9.19 (Reserved for) Altitude Constraint Type

A two-bit field is reserved in the TC Report for future use as a "Altitude Constraint Type" field. In ADS-B systems that conform to this version of this MASPS (DO-242A), the "Reserved for Altitude Constraint Type" field shall (R3.xx) be ZERO.

Note: See Appendix N for description and intended specifications for a future "Altitude Constraint Type" TC report element.

3.4.9.20 (Reserved for) Able/Unable Altitude Constraint

A one-bit field is reserved in the TC Report for future use as a "Able/Unable Altitude Constraint" flag. In ADS-B systems that conform to this version of this MASPS (DO-242A), the "Reserved for Able/Unable Altitude Constraint" field shall (R3.xx) be ZERO.

Note: See Appendix N for a description of intended function and specifications for a future "Able/Unable Altitude Constraint" TC report element.

3.4.9.21 (Reserved for) Vertical Conformance

A one-bit field is reserved in the TC Report for future use as a "Vertical Conformance" flag. In ADS-B systems that conform to this version (DO-242A) of this MASPS, the "Reserved for Vertical Conformance" field shall (R3.xx) be ZERO.

Note: See Appendix N for a description and intended specifications for a future "Vertical Conformance" TC report element.

3.4.9.22 Command or Planned Trajectory (Vertical)

<< NEW TEXT TO BE PROVIDED BY RICHARD >>

The Vertical Command/Planned flag is a one bit field that informs the data user as to the reliability of vertical TC data. (For more details, see section 7 of Appendix N.) The bit field shall (R3.xx) be set to Zero for Planned trajectory segments, and set to One for Command trajectory segments. The default value for this field is Zero, i.e. the flag should indicate a Command trajectory only for the conditions specified below.

The Vertical Command/Planned flag is set based on several possible circumstances. If the active flight segment is being flown in an autopilot mode (vertical Target Source Indicator (TSI) = 0 or 1) then all the following vertical TCRs are Planned segments. Otherwise, if the active flight segment is being flown in an FMS VNAV mode (TSI=2), then the initial TCR is a vertical Command segment. Subsequent TCR's are also Command segments, unless one has a Target Altitude TCP type. If one of the TCR's has a Target Altitude Type, then that TC report is a Command segment, and all subsequent TC reports are Planned segments since the target altitude is potentially an autopilot limiting value. (See Figure 5 and Table 6 in Appendix N for an example scenario with multiple TC reports.)

3.4.9.23 TC Report Management

TC reports will need to be managed on both transmit and receive subfunctions of ADS-B and the applications that use intent information. In this version of the MASPS (DO-242A), only TC+0 reports are specified, so only single TC reports need to be managed. The management actions to be taken are dictated by the values of the TC Report Cycle Number (§3.4.9.5) and the Trajectory Change Management Indicator (TCMI) (§3.4.9.6). In future versions of this MASPS, multiple TC reports will be supported and the management of those reports will be much more complicated. Appendix N discusses some of the factors that will need to be considered when handling multiple TC reports.

3.4.9.23.1 Transmit Subsystem TC Report Management

If the received TC Cycle Number is the same the value contained in the current TC+0 report, and the TCMI = 0, then the current TC+0 report is being refreshed with updated data. In this case, the report assembly function shall (R3.xx) refresh the TOA and TTG fields of the TC+0 report.

If the received TC Cycle Number is the same the value contained in the current TC+0 report, and the TCMI = 1, then the current TC+0 report is considered invalid. In this case, the report assembly function shall (R3.xx) set the "Horizontal Data Available and Horizontal TC Type" and "Vertical Data Available and Vertical TC Type" fields to 0. If a TC+0 report is considered invalid and no subsequent TC+0 reports are to be immediately issued, the current TC+0 report shall (R3.xx) continue to be broadcast for a time period of at least twice the required update interval for TC reports as specified in §3.3.3.1.4 (with the TCMI set to 1 and "Data Available" fields set to 0).

If the received TC Cycle Number has been incremented (modulo 4) from the current TC+0 report, and the TCMI = 0, then a new TC+0 report is being generated. In this case, the report assembly function shall (R3.xx) reinitialize all TC report fields and generate the new TC+0 report.

If the received TC Cycle Number has been incremented (modulo 4) from the current TC+0 report, and the TCMI = 1, then the current TC+0 report is considered invalid. In this case, the report assembly function shall (R3.xx) set the "Horizontal Data Available and Horizontal TC Type" and "Vertical Data Available and Vertical TC Type" fields to 0. If a TC+0 report is considered invalid and no subsequent TC+0 reports are to be immediately issued, the current TC+0 report shall (R3.xx) continue to be broadcast for a time period of at least twice the required update interval for TC reports as specified in §3.3.3.1.4 (with the TCMI set to 1 and "Data Available" fields set to 0). <<Same as is TC Cycle number matches, so make this only dependant on TCMI??>>

3.4.9.23.2 Receive Subsystem TC Report Management

If a message is received supporting TC+0 reports from a participant with the TC Cycle Number matching that of previously received reports, and the TCMI = 0, the message will be considered an update for the current TC+0 report. In this case the report assembly function shall (R3.xx) update report fields with the received data.

If a message is received supporting either TC+0 or SC reports from a participant with the TC Cycle Number matching that of previously received TC+0 reports, and the TCMI = 1, the message will be considered as an indication that current TC+0 report is no longer valid. In this case the report assembly function shall (R3.xx) clear the current TC+0 report by setting the "Horizontal Data Available and Horizontal TC Type" and "Vertical Data Available and Vertical TC Type" fields to 0 and the TTG field to its maximum value.

If a message is received supporting TC+0 reports from a participant with the TC Cycle Number incremented (modulo 4) from that of previously received reports, and the TCMI = 0, the message will be considered an new TC+0 report. In this case the report assembly function shall (R3.xx) clear all report fields and begin building a new TC+0 report with the received data.

If a message is received supporting either TC+0 or SC reports from a participant with the TC Cycle Number incremented (modulo 4) from that of previously received TC+0 reports, and the TCMI = 1, the message will be considered as an indication that current TC+0 report is no longer valid. In this case the report assembly function shall (R3.xx) clear the current TC+0 report by setting the "Horizontal Data Available and Horizontal TC Type" and "Vertical Data Available and Vertical TC Type" fields to 0 and the TTG field to its maximum value. <<Same as is TC Cycle number matches, so make this only dependant on TCMI??>>

invalid and no subsequent TC+0 reports are to be immediately issued, the current TC+0 report will continue to be broadcast for a time period of at least twice the required update interval for TC reports as specified in §3.3.3.1.4 (with the TCMI set to 1 as specified in §3.4.9.6 above)